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CALCULATOR - AIDED
MICROWAVE NETWORK ANALYSIS

John Calhoun Carlton

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Monterey, California



THESIS

CALCULATOR - AIDED
MICROWAVE NETWORK ANALYSIS

by

John Calhoun Carlton, Jr.

December 1974

Thesis Advisor:

Jeffrey B. Knorr

Approved for public release; distribution unlimited.

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Calculator - Aided
Microwave Network Analysis

by

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B.S., University of Florida, 1967

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requirements for the degree of

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ABSTRACT

The HP-8410S Microwave Network Analyzer System and the Wang 600 Programmable Calculating and Plotting System are discussed. An interface between the two is described and the feasibility of microwave network analysis under program control is demonstrated. Four calculator programs which implement S-parameter sampling and data reduction are described and documented.

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I. INTRODUCTION

The HP-8410S Microwave Network Analyzer System enables rapid characterization of microwave network components by determining complex scattering parameters, commonly referred to as S parameters. It provides a large amount of raw data by displaying these parameters in a continuous analog plot over octave bandwidths. Even though a large amount of data is provided, recording and interpretation must still be done manually. This is time consuming, and the accuracy provided by the network analyzer can be diminished by recording and reduction errors.

With this in mind, it was felt that the network analyzer system could be enhanced by the addition of a peripheral system to automatically sample the displayed S parameters at discrete frequencies, perform data reduction, plot and list the results. The purpose of this study was to demonstrate the feasibility of such a system by interfacing the Wang 600 Programmable Calculator System and the HP-8410S Microwave Network Analyzer System and developing several software programs.

II. S PARAMETERS

A. DESCRIPTION

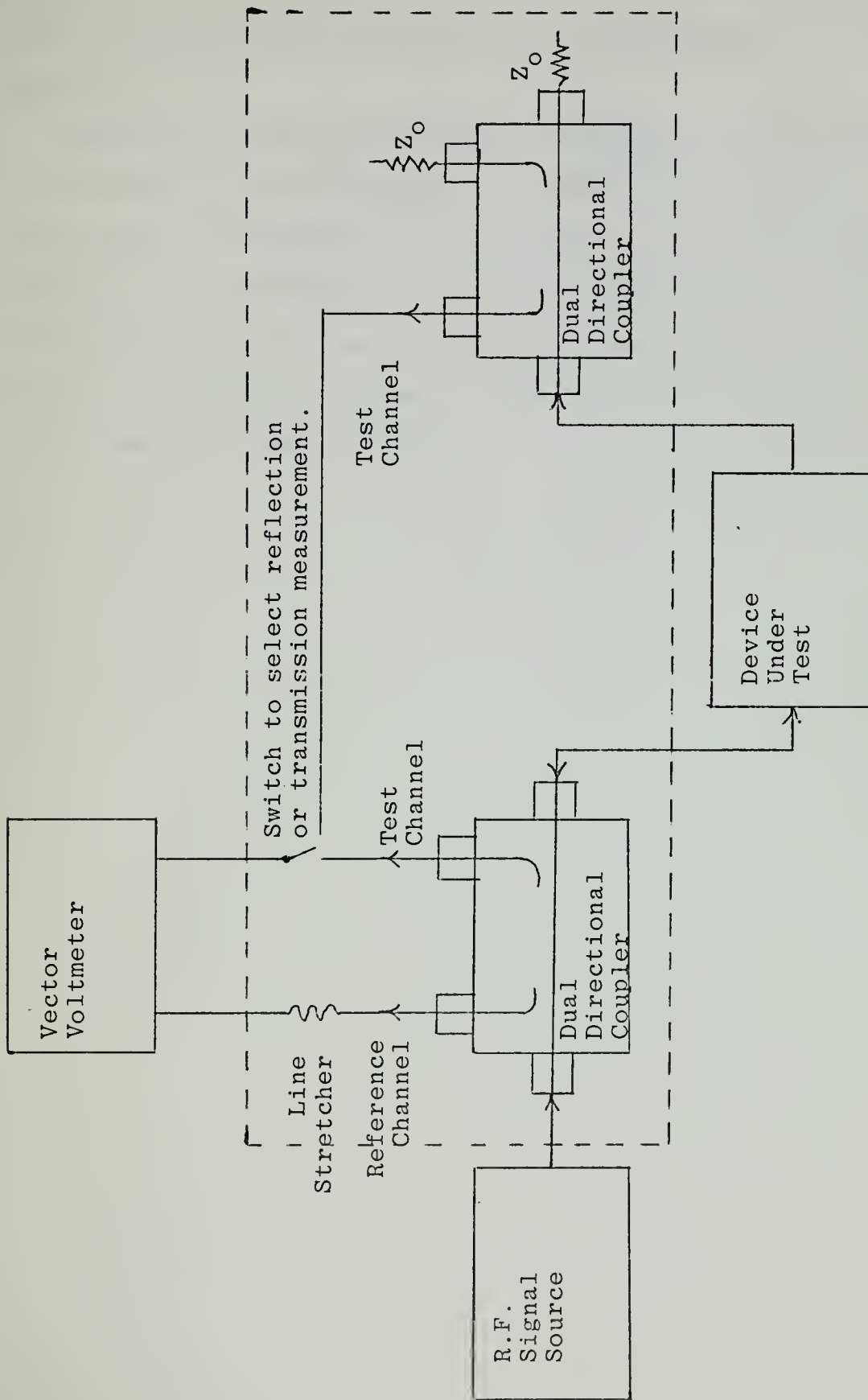
S parameters are obtained from reflection and transmission measurements of voltage waves incident on a test device. They are the ratios of complex signal voltages and contain both amplitude and phase information.

S parameters are preferred at microwave frequencies because they are measured with the device under test terminated in the characteristic impedance of the transmission line in which it is inserted. As a result, stray capacitance and lead inductance caused by open and short circuit terminations are eliminated. Also, semiconductor devices do not oscillate under test.

B. MEASUREMENT TECHNIQUE

A means of determining S parameters is by use of two dual directional couplers with the device to be tested inserted between and the system fed by a high frequency signal source. This technique is shown in block diagram form in Figure 1.

The ratio of the reference and test channel signals is obtained with a vector voltmeter. The characteristic impedance terminations on the second directional coupler prevent reflections. With this arrangement, S_{11} and S_{21} can be determined. To obtain S_{22} and S_{12} , the two



S - Parameter Measurement Technique

Figure 1

port device is turned around and the measurements repeated.

The part of the block diagram enclosed by dotted lines is referred to as a transducer. It splits the incoming signal into a reference and test channel, and provides the capability of extending the electrical length of the reference channel so that the reference and test signals travel the same electrical distance. This preserves the phase relationship between the two.

III. SYSTEM DESCRIPTION

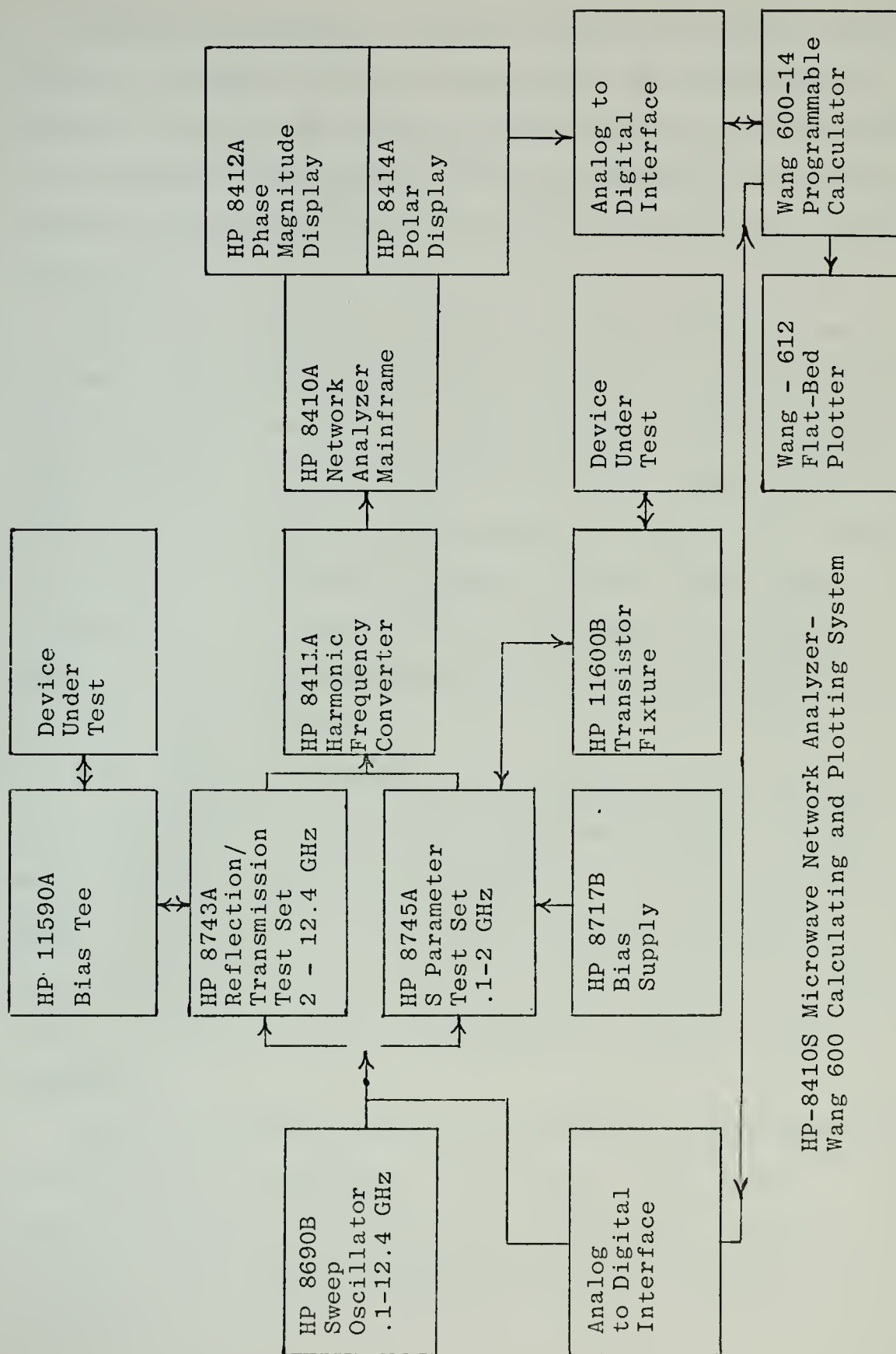
Figure 2 is a block diagram of the HP-8410S Microwave Network Analyzer - Wang 600 Calculating and Plotting System which is installed in the Naval Postgraduate School Microwave Laboratory.

A. MICROWAVE NETWORK ANALYZER

The HP-8690B Sweep Oscillator with the HP-8690B series RF plug-ins serves as the signal source for one of two transducers, either the HP-8743A Reflection-Transmission Test Unit or the HP-8745A S-Parameter Test Set, depending on the frequency range of operation desired.

These transducers are capable of both reflection and transmission measurements. They use dual directional couplers to split the incoming signal into reference and test channels. The device under test is connected to the front panel. Coaxial switches, operated by pushbuttons, connect the system correctly for the type measurement desired.

Available with the transducers are the HP-11600B Transistor Fixture, HP-8717B bias Supply and HP-11590A Bias Tee, which allow S parameter characterization of active semiconductor devices. Bipolar Transistors, FET's, diodes, negative resistance transferred electron devices, etc. can be easily and quickly analyzed for any specified bias condition.



HP-8410S Microwave Network Analyzer-Wang 600 Calculating and Plotting System

Figure 2

The HP-8411A Harmonic Frequency Converter receives the test and reference channel signals from the transducer and converts them over a range of 0.11 to 12.4 GHz to a 20.278 MHz IF. Since the conversion is linear, the test and reference channel IF signals maintain their same relative amplitudes and phases.

Comparison of the two signals is accomplished by low frequency circuitry in the displays mounted in the HP-8410A Network Analyzer Mainframe. The mainframe provides phase-lock circuitry over an octave bandwidth to maintain the 20.278 MHz IF while frequency is being swept. It takes the ratio of the test and reference signals and then converts down to a second IF of 278 KHz. It has a precision 0 to 69 dB attenuator for accurate measurement of gain or attenuation of test channel amplitude.

The measured S parameters are displayed on the HP-8414A Polar Display or HP-8412A Phase-Magnitude Display. If the polar display is used, the parameters are read directly as magnitude and angle. If the phase-magnitude display is used, the parameters are in the form of return loss in dB, insertion loss or insertion gain in dB and phase in degrees versus frequency.

The polar display is most often used for measurement of reflection and transmission coefficients. The phase-magnitude display is effective for determining filter response such as skirt steepness and phase response linearity.

Smith Chart overlays are available with the polar display. These allow direct reading of normalized impedance in the case of reflection measurements since the Smith Chart is defined by $\frac{Z}{Z_0} = \frac{1 + \Gamma}{1 - \Gamma}$ where Γ is the reflection coefficient of the device under test and Z_0 is the characteristic impedance of the transmission line in which the device is inserted.

B. CALCULATOR - PLOTTER

The Wang 600-14 Programmable Calculator has a programmable memory which allows program control of any operation which the calculator is capable of manually. It has a decision-making capability which allows branching and looping in programs. To write a program, the calculator is placed in the "Learn" mode and the sequence of operations desired is keyed. This results in the generation of four digit codes which are stored sequentially in memory. Each four digit code corresponds to a specific keyboard operation or a specific function selection and its corresponding register number. For example, the code 0815 means to take the number in the display register, invert it and put the result back in the display register. The code 0405 means to multiply the number in register five by the number in the display register and place the result back in register five.

To execute a program, the calculator is placed in the "Run" mode and the program is initiated by the operator. If the program has "Bugs," the calculator is again placed in the "Learn" mode and the program is stepped through. Each

program instruction is displayed as it is reached and is checked for correctness by the operator. When an incorrect code is found, the correct code is merely keyed in at the same location.

Programs can be recorded on magnetic tape for storage and future use. When a program which is on tape is needed, it is loaded directly into memory from the tape.

There are sixteen basic registers available for data storage. If only these sixteen are used, then programs up to 1,848 steps can be written. If the need arises for more than sixteen data storage registers, the calculator adapts by changing program step storage area into data storage registers. This is accomplished by taking eight program steps and grouping them together to form one register. If the entire memory is used for data storage registers, then there are 247 available.

The Wang Model 612 Flat-Bed Plotter provides line or point plotting and alphanumeric labeling. Format and content of the labeling is controlled by the calculator.

IV. ANALOG TO DIGITAL INTERFACE

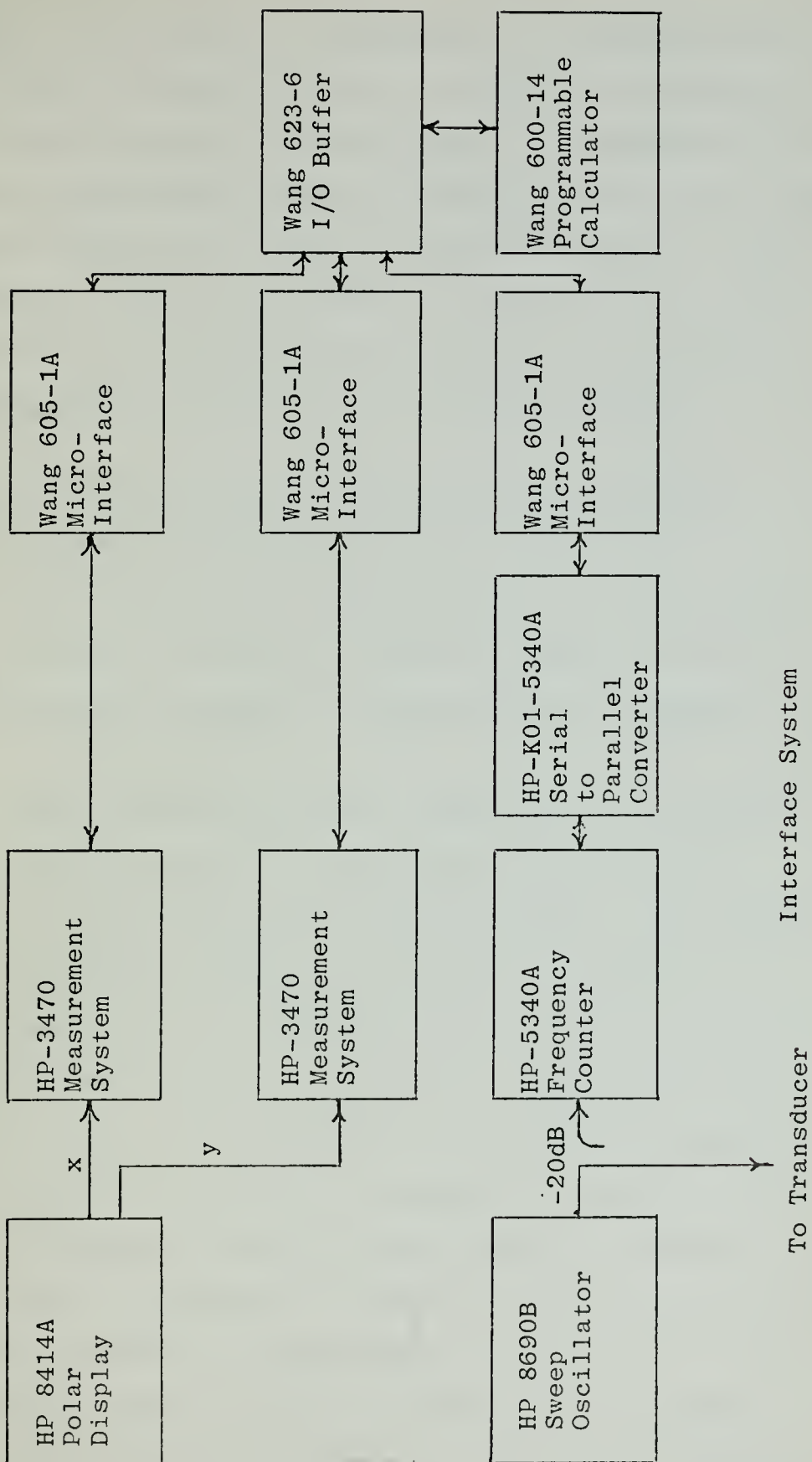
The analog to digital interfaces shown in Figure 2 were implemented by the author. A block diagram of the interface system is shown in Figure 3.

In the rear of the polar display, horizontal and vertical voltages directly proportional to the CRT deflection voltages are available. They are fed into two HP-3470 Measurement Systems where they are converted from analog to bit parallel character parallel 8421 BCD. After transfer to Wang 605-1A Micro Interfaces, these voltages are further converted to serial hexadecimal.

A portion of the output from the sweep oscillator is routed to a HP-5340A Frequency Counter by a -20dB directional coupler. After passing through the counter and a KO1-5340A Serial to Parallel Converter, the frequency enters a micro-interface as bit parallel character parallel 8421 BCD and is converted to serial hexadecimal.

Since three micro-interfaces are used, they are connected to a Wang 623-6 I/O Buffer to alleviate fan-out problems. The micro-interfaces transfer the voltages and frequency in serial hexadecimal form through the I/O buffer into the calculator's display register.

To implement the interface, it was necessary to compare connector diagrams of a micro-interface, a BCD module and the serial to parallel converter. These are shown in Figures



4, 5, and 6. As a result of comparison, the connectors were wired as listed in Tables I and II. Logic level switches on the micro-interfaces were set as follows. For connection to BCD module; sign, down; print, up; execute, down; logic level, down. For connection to serial to parallel converter; sign, doesn't matter; print, up; execute, up; logic level, down.

A description of each interface component and control signal interaction is given in the following section.

A. INTERFACE COMPONENT AND CONTROL SIGNAL DESCRIPTION

The Wang 605-1A Micro-Interface is an input-only interface which accepts up to seven digits plus sign of bit parallel character parallel 8421 BCD and converts it into serial hexadecimal for input to the calculator's display register.

Input logic levels are TTL/DTL compatible with nominal values of zero volts for "0" state and +5 volts for "1" state. One output and one input control signal are provided and are respectively "Execute" and "Print." "Execute" is a switch selectable d.c. condition of zero volts or +5 volts, and indicates that the micro-interface is ready to receive data. "Print" is an input strobe of 5 microsecond minimum duration which can be positive or negative. A switch allows the micro-interface to adapt to either polarity. "Print" indicates that the peripheral to which the micro-interface is attached is about to transfer data.

Two 36 wire cables are used for data input and output. The output cable is factory wired to a 36 pin male Amphenol

Micro-Interface Connector Diagram

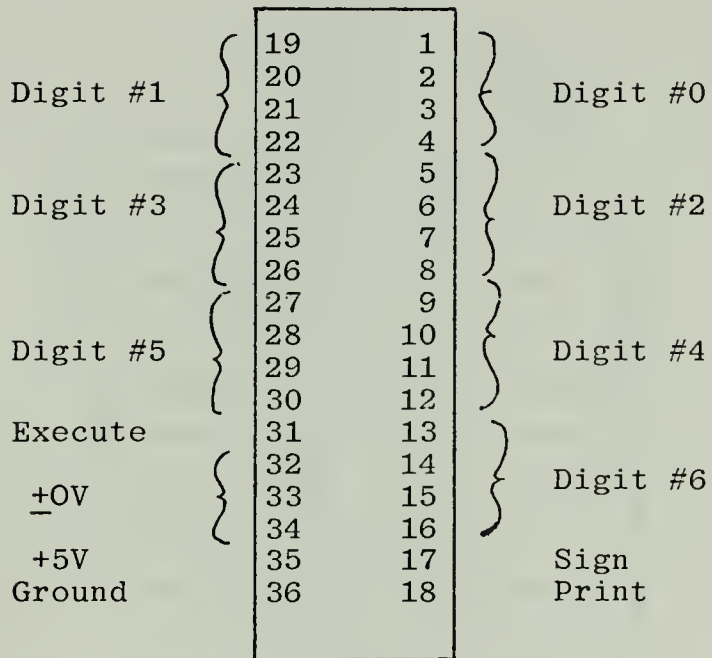


Figure 4

BCD Module Connector Diagram

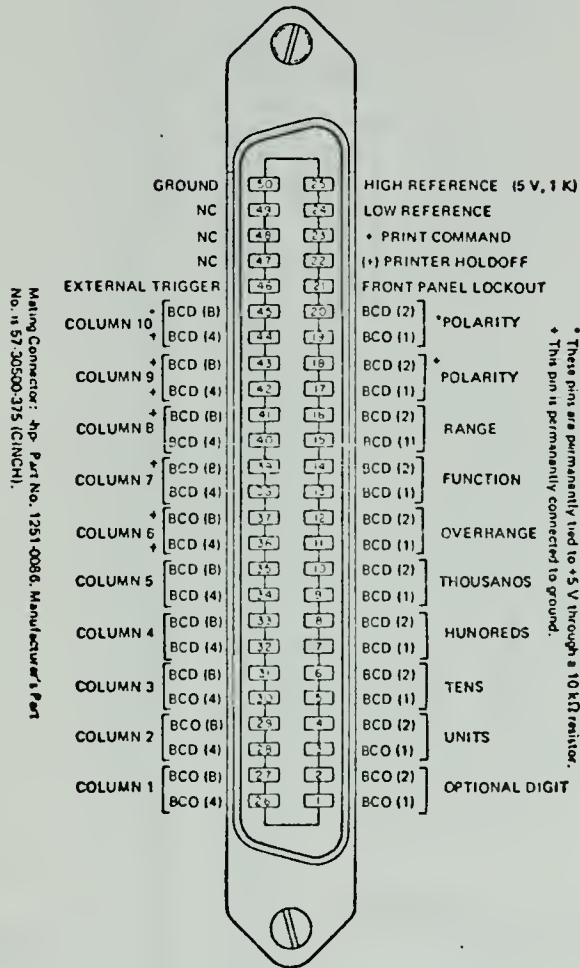


Figure 5

Serial to Parallel Converter Connector Diagram

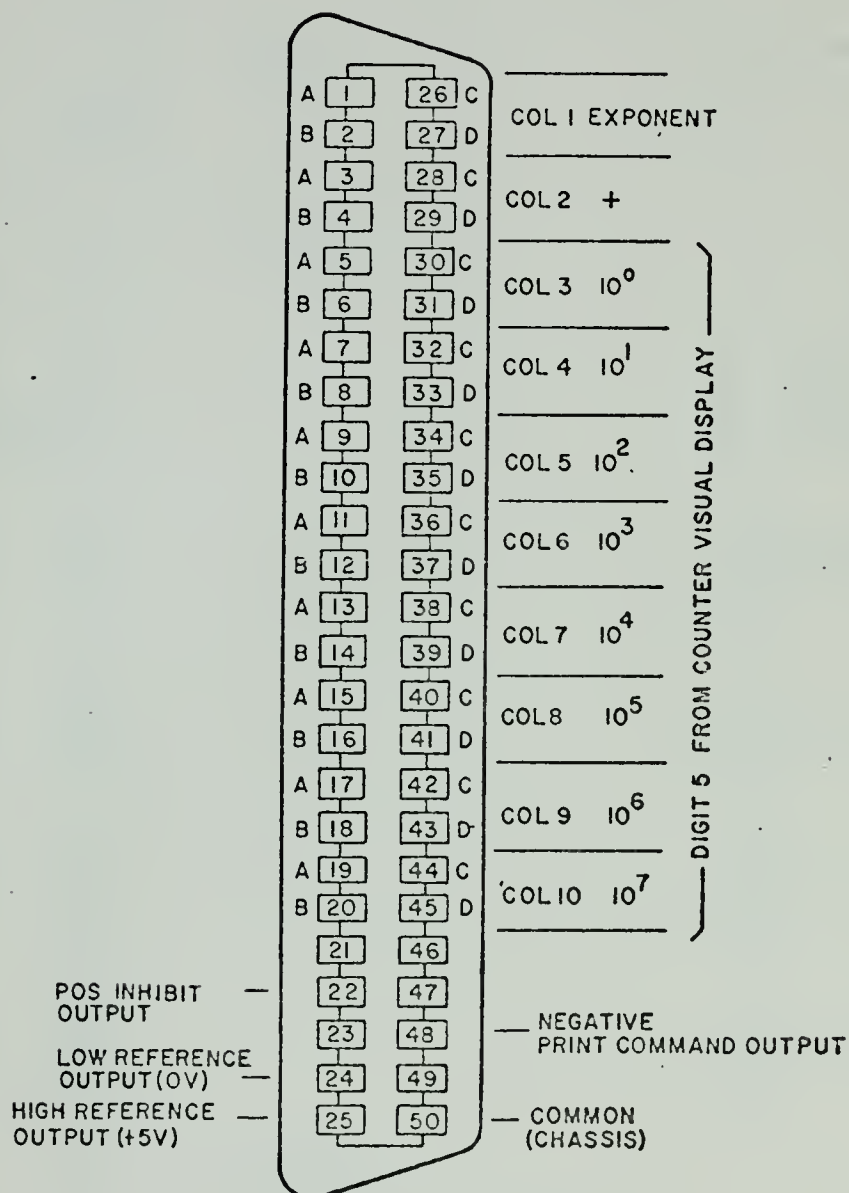


Figure 6

MICRO-INTERFACE-BCD MODULE WIRING LIST

Micro-Interface Wire Numbers		BCD Module Connector Pin Numbers	
Digit #0	$\left\{ \begin{array}{l} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 7 \\ 32 \\ 33 \\ 34 \end{array} \right\}$	bundle	24 $\pm$ 0 Volts
	6	unconnected	
	8	"	
Ground	36	"	
Sign	17	19	Polarity
Print	18	23	Print
Execute	31	46	External Trigger
+5 Volts	35	25	+5 Volts
Digit #6	$\left\{ \begin{array}{l} 13 \\ 14 \\ 15 \\ 16 \end{array} \right\}$	$\left\{ \begin{array}{l} 1 \\ 2 \\ 26 \\ 27 \end{array} \right\}$	Optional Digit
Digit #5	$\left\{ \begin{array}{l} 27 \\ 28 \\ 29 \\ 30 \end{array} \right\}$	$\left\{ \begin{array}{l} 3 \\ 4 \\ 28 \\ 29 \end{array} \right\}$	Units
Digit #4	$\left\{ \begin{array}{l} 9 \\ 10 \\ 11 \\ 12 \end{array} \right\}$	$\left\{ \begin{array}{l} 5 \\ 6 \\ 30 \\ 31 \end{array} \right\}$	Tens
Digit #3	$\left\{ \begin{array}{l} 23 \\ 24 \\ 25 \\ 26 \end{array} \right\}$	$\left\{ \begin{array}{l} 7 \\ 8 \\ 32 \\ 33 \end{array} \right\}$	Hundreds
Digit #2	$\left\{ \begin{array}{l} 5 \\ 6 \\ 7 \\ 8 \end{array} \right\}$	$\left\{ \begin{array}{l} 5 \\ 6 \\ 30 \\ 31 \end{array} \right\}$	Tens
	to bundle		
	unconnected		
	to bundle		
	unconnected		
		Generates Decimal Point	
Digit #1	$\left\{ \begin{array}{l} 19 \\ 20 \\ 21 \\ 22 \end{array} \right\}$	$\left\{ \begin{array}{l} 9 \\ 10 \\ 34 \\ 35 \end{array} \right\}$	Thousands

TABLE I

MICRO-INTERFACE-SERIAL TO PARALLEL CONVERTER WIRING LIST

Micro-Interface Wire Numbers		Serial to Parallel Converter Connector Pin Numbers	
±0 Volts	32 33 34 }	bundle	24 ±0 Volts
Sign	17	unconnected	
Ground	36	"	
Print	18		48 Print
Execute	31		22 Inhibit
+5 Volts	35		25 +5 Volts
Digit #6	13 14 15 16 }		1 2 26 27 } Exponent
Digit #5	27 28 29 30 }		9 10 34 35 } 10 ²
Digit #4	9 10 11 12 }		11 12 36 37 } 10 ³
Digit #3	23 24 25 26 }		13 14 38 39 } 10 ⁴
Digit #2	5 6 7 8 }		15 16 40 41 } 10 ⁵
Digit #1	19 20 21 22 }		17 18 42 43 } 10 ⁶
Digit #0	1 2 3 4 }		19 20 44 45 } 10 ⁷

TABLE II

connector and plugs into the I/O buffer. The input cable has one end factory wired to a 36 pin male Amphenol connector which plugs into the micro-interface. The other end consists of 36 exposed, numbered wires which can be wired to a suitable connector for attachment to a peripheral.

The HP-3470 Measurement System consists of a HP-34701A DC Voltmeter, a HP-34740A Display and a HP-34721 BCD Module. The d.c. voltmeter reads an analog voltage, the display converts it into character serial digital form and displays it. The BCD module converts the character serial data from the display into bit parallel character parallel 8421 BCD for input to a HP-5055A Digital Recorder or equivalent. In this case, the input is to a micro-interface rather than a digital recorder. BCD module output is through a 50 pin rear panel connector. Ten columns are available, five are for the digits in the Display, one for overrange, one for function, one for range and two for polarity.

The d.c. voltmeter has four voltage ranges of operation, 0 to +1, 0 to +10, 0 to +100, and 0 to +1000. The display has four digits plus an overrange digit which completes the readout on measurements above full scale up to 100% overrange. When 100% overrange is reached, all digits except the overrange digit are blanked.

The maximum useable x or y output from the polar display is +2.1 volts. Therefore, the 0 to +1 volt range on the d.c. voltmeter cannot be used because even with the overrange digit feature on the display, the maximum voltage which can

be displayed is 1.9999 volts. Any larger voltage yields 1.____. Thus, the 0 to ±10 volt range is used. This range gives a digital output adequate to cover the x and y voltage range with three decimal point accuracy.

The logic level of the BCD module is the same as that of the micro-interface. It allows for three input control signals, "Front Panel Lockout," "(+) Printer Hold-off," and "External Trigger," and provides one output control signal, "Print." The input control signal of consequence here is "External Trigger," which is a +5 volt d.c. pulse of one microsecond minimum duration.

With the front panel output rate switch in the hold position, the display will be sampled by the BCD module only when the "External Trigger" pin is at +5 volts or the "Manual" pushbutton is pressed. When the micro-interface sends its "Execute" command to the external trigger pin on the BCD module connector, it responds by sequentially transferring the data in the display into output data registers. During this transfer, conversion from bit parallel character serial 8421 BCD to bit parallel character parallel 8421 BCD occurs.

The BCD module next sends its "Print" command, followed by the parallel transfer of the number in its output data registers to the micro-interface. Once there, this number is converted to serial hexadecimal and transferred into the display register of the calculator. When transfer is complete, the "Execute" command from the micro-interface is returned to its original d.c. state of 0 volts and control is returned to the calculator.

The HP-5340A Frequency Counter provides a digital display of measured frequency and outputs bit parallel character serial "1" state negative ASCII to a 24 pin rear panel connector. A HP-K01-5340A Serial to Parallel Converter is used to convert this into bit parallel, character parallel 8421 BCD for input to a HP-5050A/B or HP-5055A Digital Recorder with the counter functioning as "Talker" and the recorder as "Listener." In this case, the input is to a micro-interface rather than a digital recorder.

The serial to parallel converter has as input from the frequency counter a 24 wire cable and as output a 50 pin connector which outputs ten columns of bit parallel character parallel 8421 BCD. Eight columns are for the digits displayed in the window of the frequency counter, and two columns are for a positive single digit exponent. The exponent is used to designate decimal point location with hertz as the measurement unit. Blanked zeros in the frequency counter's display are output as zeros by the serial to parallel converter. The 50 pin connector provides one input command, "Inhibit," and one output command, "Print." Logic levels are the same as those of the micro-interface.

Unlike the BCD module, which can have its sample and output rate controlled by "External Trigger," the converter was designed to enable the frequency counter to operate in the "Talk Always" mode to a digital recorder. This means that no "External Trigger" input is available to control sample and output rate. The frequency counter samples its

display window and issues a "Print" command at the rate determined by its internal rate generator. However, the converter provides a means by which the frequency counter will not output data until a record cycle is complete. When the frequency counter samples a frequency and generates a BCD output, the converter issues a "Print" command to the digital recorder. The recorder responds with an "Inhibit" command which causes the converter to prevent any further frequency sampling by the counter. The recorder removes the "Inhibit" command when recording is complete. The converter then allows another count-record cycle to be started.

In order to control sample and output rate of the frequency counter, the "Execute" command line from the micro-interface is connected to the "Inhibit" pin on the converter and has its logic level set so that when the micro-interface is not requesting data from the frequency counter, +5 volts are applied to the "Inhibit" pin of the converter. When the micro-interface sends its "Execute" command to the converter, the +5 volts are removed. This causes the converter to allow the frequency counter to function and send data to the converter which issues a "Print" command and transfers the data to the micro-interface. After the data is transferred to the calculator's display register, the "Execute" command is removed and +5 volts are again applied to the "Inhibit" pin of the converter, thus preventing any further sampling by the counter.

B. DIGIT WIRING

Any one of the seven input digits to the micro-interface can be wired to generate a decimal. Since four significant digits are transferred from the BCD module to the micro-interface, and since the voltages measured are always within the 10 volt range of the d.c. voltmeter, the micro-interface is wired to generate a decimal which follows the most significant digit of the input voltage. This was accomplished by wiring digit #2 on the micro-interface as a decimal. The least significant digit of the input voltage is wired to digit #5, the most significant to digit #1. The other digits are wired in order between. Digit #0 is unused and digit #6 is wired to the optional digit input from the BCD module.

If the HP-34750A Display were used instead of the HP-34740A Display, the optional digit would give another decimal point of accuracy. Since the HP-34740A Display is used, the optional digit always appears as a zero when transferred to the calculator's display register.

Eight digits, a plus sign and an exponent are output by the serial to parallel converter. The micro-interface can only accept seven digits. Therefore, only the six most significant digits of the frequency measurement and the exponent are wired to the micro-interface connector. The plus sign which precedes the exponent is unnecessary. The exponent digit is wired to digit #6 on the micro-interface and the most significant digit of the frequency is wired to digit #0. The other digits are wired in order between.

Since two digits of the frequency are not sent to the micro-interface, the exponent is in error and must have two added to it to give a correct reading when displayed in the calculator's display register. This is accomplished with a short calculator subroutine.

V. CALCULATOR PROGRAMMING

Four programs to demonstrate the feasibility of calculator-aided microwave network analysis were written by the author. In general terms they can be described as follows.

The x and y voltages from the polar display and the frequency of the sweep oscillator's output are called for sequentially by the calculator. Each micro-interface has a switch selectable address which can be any number from 00 through 15. When a calculator program requires raw data, the calculator transfers control to a micro-interface, which then interrogates the peripheral to which it is attached. The peripheral responds with the data to the micro-interface, which transfers it to the calculator's display register. Once in the display register, it is moved to a storage location.

When this cycle is complete, program control returns to the calculator and another micro-interface is given control, or if the data sampling desired by the program is finished, then data reduction proceeds in the calculator.

The reduced data is stored by the calculator and then plotted by the plotter under program control in the form desired. The data can also be listed beside the plot or printed out on the calculator's 21-column drum printer.

A. S_{11}/S_{22} - PRINTING

This program uses the calculator's 21-column drum printer to type out ten items derived from reflection measurements using the polar display. These are frequency, VSWR, $\text{Re } \Gamma$, $\text{Im } \Gamma$, $|\Gamma|$, $\angle \Gamma$, $\text{Re } z$, $\text{Im } z$, $|z|$, and $\angle z$. The Program is designed to be executed on a point by point basis i.e. a point is taken and the reduced data typed out before another point is taken.

Figure 7 shows a typical output.

B. SMITH CHART - PLOTTING AND LISTING

This program uses the plotter as the output device and is designed for reflection measurements on the polar display. A maximum of 41 data points can be taken. Forty-two or more will cause data to be stored in memory locations which contain program steps and will result in program errors. A simplified Smith Chart is drawn and the points plotted on it. Frequency and real and imaginary parts of normalized impedance of each point are listed beside the chart.

The program can be used for devices which exhibit a negative real part of impedance ($\Gamma > 1$), such as transferred electron devices, as well as devices which have a positive real part of impedance ($\Gamma \leq 1$). This flexibility results from a routine which tests each point before it is plotted to determine if $\Gamma > 1$ or if $\Gamma \leq 1$. If $\Gamma > 1$, the location of the point to be plotted on the Smith Chart is obtained from the inverse of the complex conjugate of the measured

Reflection measurement of input to a JAN2N3866 Transistor
 at .5004 GHz. Bias Conditions; $V_{CE} = 5$ Volts, $I_E = 50$ ma.

	$5,004 \times 10^5$ Hz	
Frequency	50045.0000	D
VSWR	3.5573	D
Re Γ	-.3866	D
Im Γ	.4066	D
$ \Gamma $	.5611	D
$\angle \Gamma$	133.5558	D
Re z	.3280	D
Im z	.3894	D
$ z $	.5092	D
$\angle z$	-310.1091	D

Figure 7

reflection coefficient. The Smith Chart lines of constant resistance are then interpreted as negative and the impedance print out has its real part negative. If $\Gamma \leq 1$, the location of the point is obtained from the unchanged measured reflection coefficient, the lines of constant resistance are interpreted as positive and the impedance print out has its real part positive.

To measure $\Gamma > 1$, the display must be compressed to place the point on the CRT. This is accomplished by attenuating the test channel signal. The difference between the dB setting necessary to calibrate the network analyzer and the attenuation in dB's applied to the test channel is entered into the program by the operator via the keyboard. The program uses this value to plot the points correctly on the Smith Chart.

Figures 8 and 9 show typical outputs.

C. S_{12}/S_{21} POLAR COORDINATES - PLOTTING AND LISTING

This program is designed for transmission measurements using the polar display. A maximum of 36 data points can be taken. Thirty-seven or more will result in program errors. A polar coordinate system is drawn and the value of the outer circle radius is printed. Frequency and magnitude and angle of each transmission coefficient are listed beside the plot.

The program can be used for transmission coefficients either larger or smaller than one. To measure a transmission coefficient with magnitude greater than one, the display must be compressed. The dB difference between calibration setting

Negative Resistance Smith Chart Plot for a GD508A Gunn Diode between 8.1 and 9.0 GHz in 0.1 GHz Steps. Bias; 7 Volts. 10 dB's of attenuation have been applied to the test channel signal.

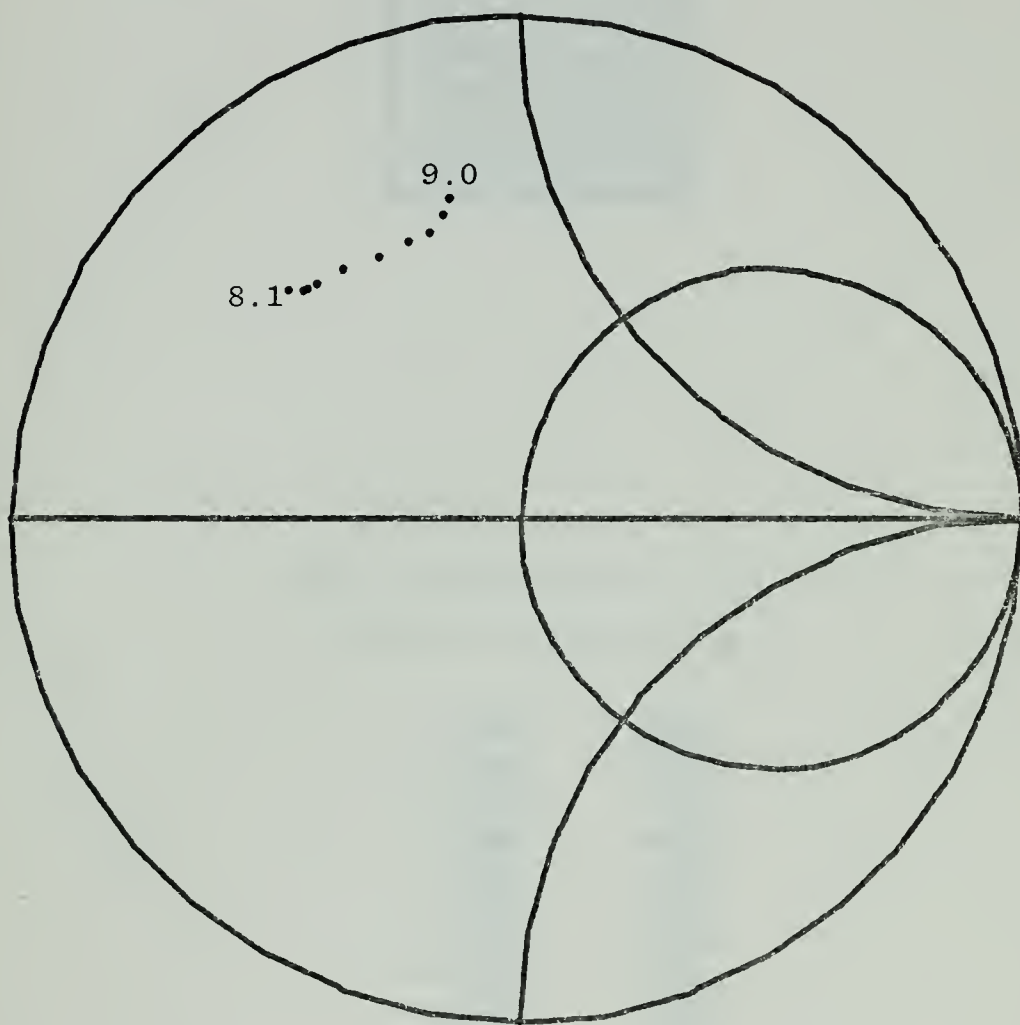


Figure 8a

Frequency in Hz

8.1012000000E08
 8.2001000000E08
 8.3001000000E08
 8.4013000000E08
 8.5007000000E08
 8.6000000000E08
 8.7020000000E08
 8.8013000000E08
 8.8012000000E08
 8.0041000000E08

Real and Imaginary Parts
 of Normalized Impedance.

-.246	.386
-.272	.410
-.278	.418
-.283	.437
-.307	.468
-.342	.557
-.380	.628
-.373	.681
-.358	.733
-.329	.768

Figure 8b

Normalized Input Impedance of a JAN2N3866 Transistor
Between .5 and 1.0 GHz in .1 GHz Steps. Bias Conditions;
 $V_{CE} = 5$ Volts, $I_E = 50$ ma.

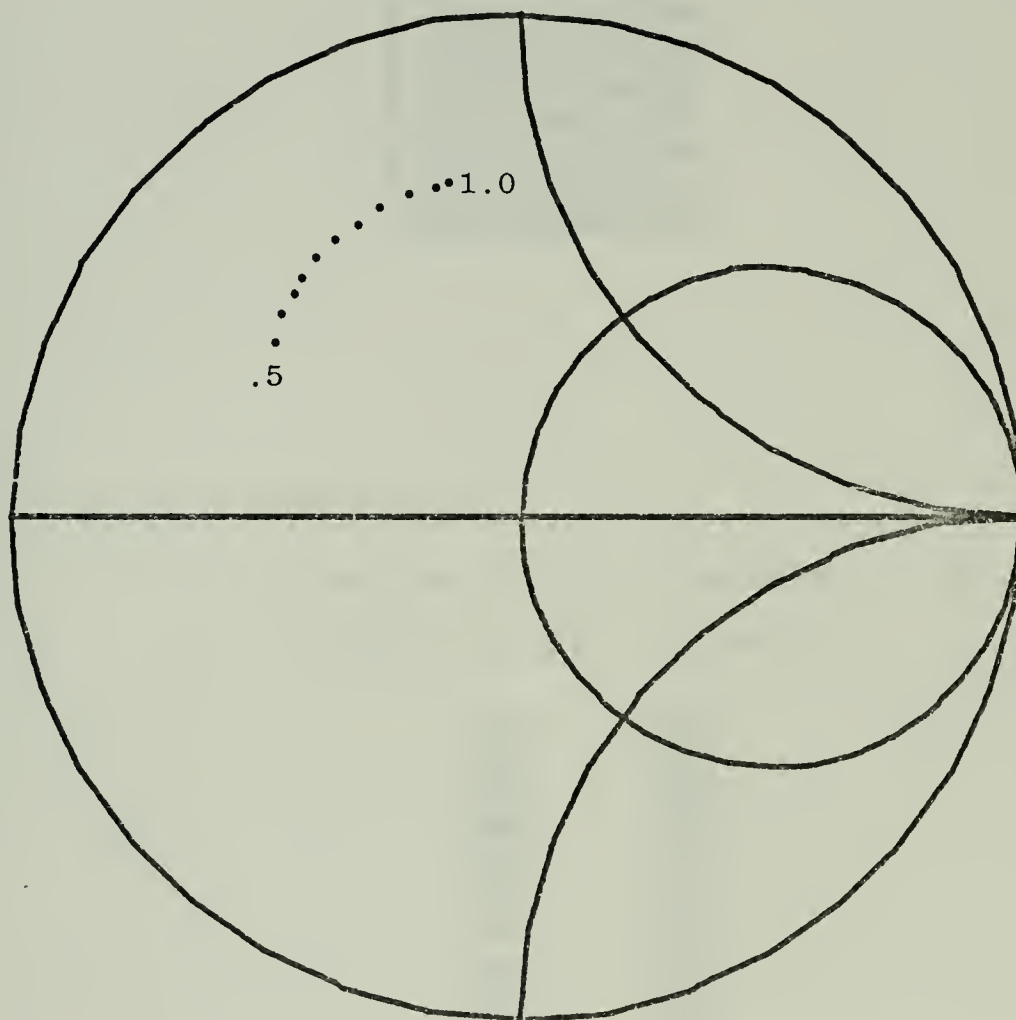


Figure 9a

Frequency in Hz

5.007022000000E03
 5.500000000000E03
 6.032000000000E03
 6.500000000000E03
 7.000000000000E03
 7.504000000000E03
 8.000000000000E03
 8.500000000000E03
 8.000000000000E03
 8.504000000000E03
 1.000000000000E03

Real and Imaginary Parts of
 Normalized Input Impedance.

.274	.304
.262	.353
.262	.388
.258	.428
.254	.472
.257	.518
.287	.571
.268	.627
.277	.684
.293	.753
.287	.785

Figure 9b

and compressed setting is entered into the program by the operator. This is used to calculate the radius of the outer circle.

One other operator entry is required, the absolute value of the x voltage when the analyzer is calibrated to a short circuit. This is used to normalize x and y voltage readings to one so that 449 plotter increments will define maximum radius regardless of actual maximum radius value. Generally, this normalizing voltage is 2.1. It should be noted that regardless of the test channel dB setting, either before or after display compression or expansion, this voltage is always produced as the maximum useable x deflection voltage.

Figure 10 shows a typical output.

D. SCHOTTKY BARRIER CAPACITANCE - PLOTTING AND LISTING

This program calculates and plots the depletion capacitance of a Schottky diode as a function of reverse bias. The Smith Chart program is used to store and plot reflection measurement points of a reverse biased Schottky diode. The diode program is then loaded into memory where the Smith Chart program is located. This replaces the Smith Chart program with the diode program. The raw data stored in memory is not disturbed by this reloading.

The diode program draws and labels a rectangular coordinate system for quadrant II. The operator then enters the bias voltages in the order used. As a voltage is entered, depletion capacitance is calculated and stored with it. The program compares the voltages and uses the largest to scale

Forward Voltage Transfer Coefficient (S_{21}) of a JAN2N3866 Transistor Between .5 and 1.0 GHz in .1 GHz Steps. Bias conditions; $V_{CE} = 5$ Volts, $I_E = 50$ ma. 6 dB's of attenuation have been applied to the test channel signal.

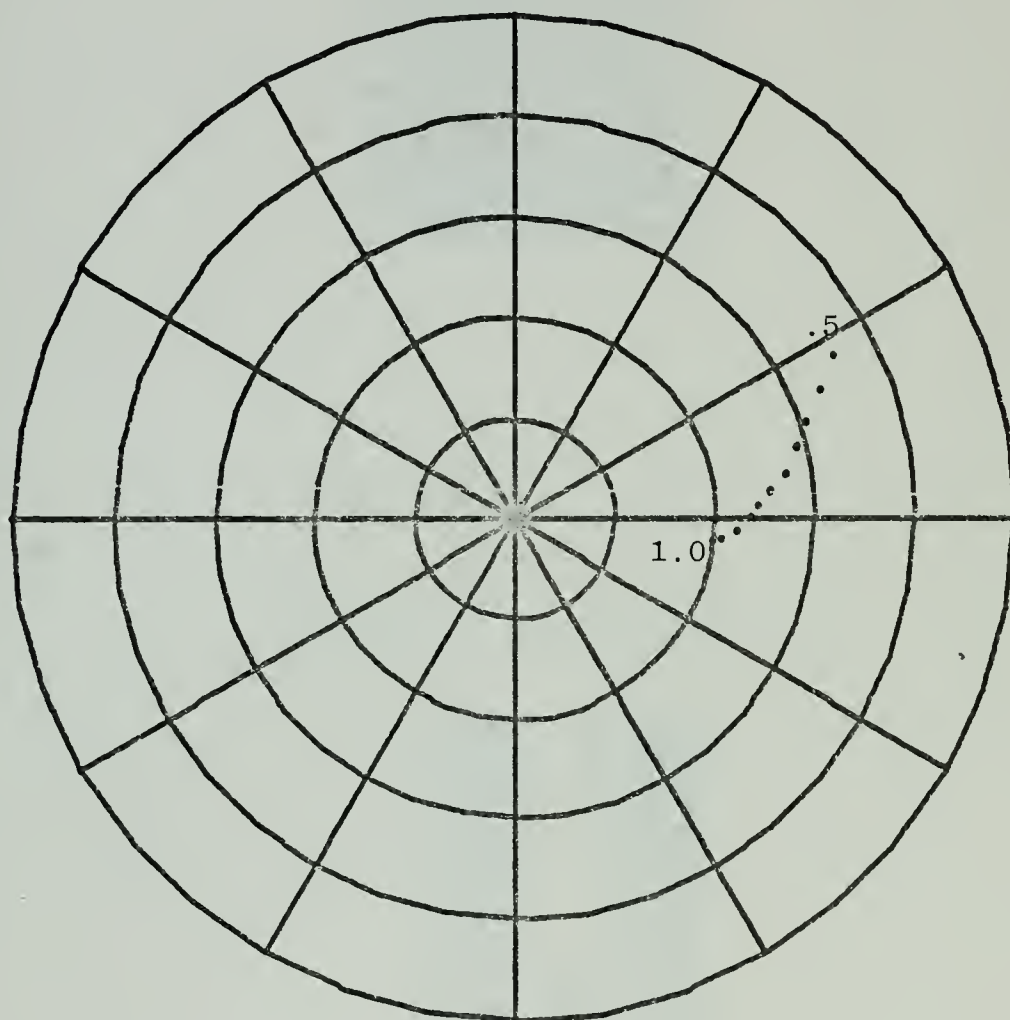


Figure 10a

Frequency in Hz

3.0240000000E08
 3.5060000000E08
 6.0200000000E08
 6.5020000000E08
 7.0030000000E08
 7.5020000000E08
 8.0260000000E08
 8.5070000000E08
 8.0130000000E08
 8.5040000000E08
 1.0020000000E09

Magnitude and Angle of S_{21}

1.433	27.590
1.320	23.171
1.216	18.830
1.152	14.888
1.078	8.470
1.024	6.138
.844	2.584
.807	359.760
.854	355.601
.782	332.827
.754	351.012

Figure 10b

the x axis. Likewise, the largest capacitance is used to scale the y axis to either 2.5 or 5 picofarads. The points are plotted and tabulated in the order taken.

Bias voltage can be applied to the diode in any order desired, but it must be entered into the program in that same order.

Figure 11 shows a typical output.

Reverse Biased Schottky Diode at 1.0 GHz. Bias; 0 to
-5 Volts in .5 Volt Increments.

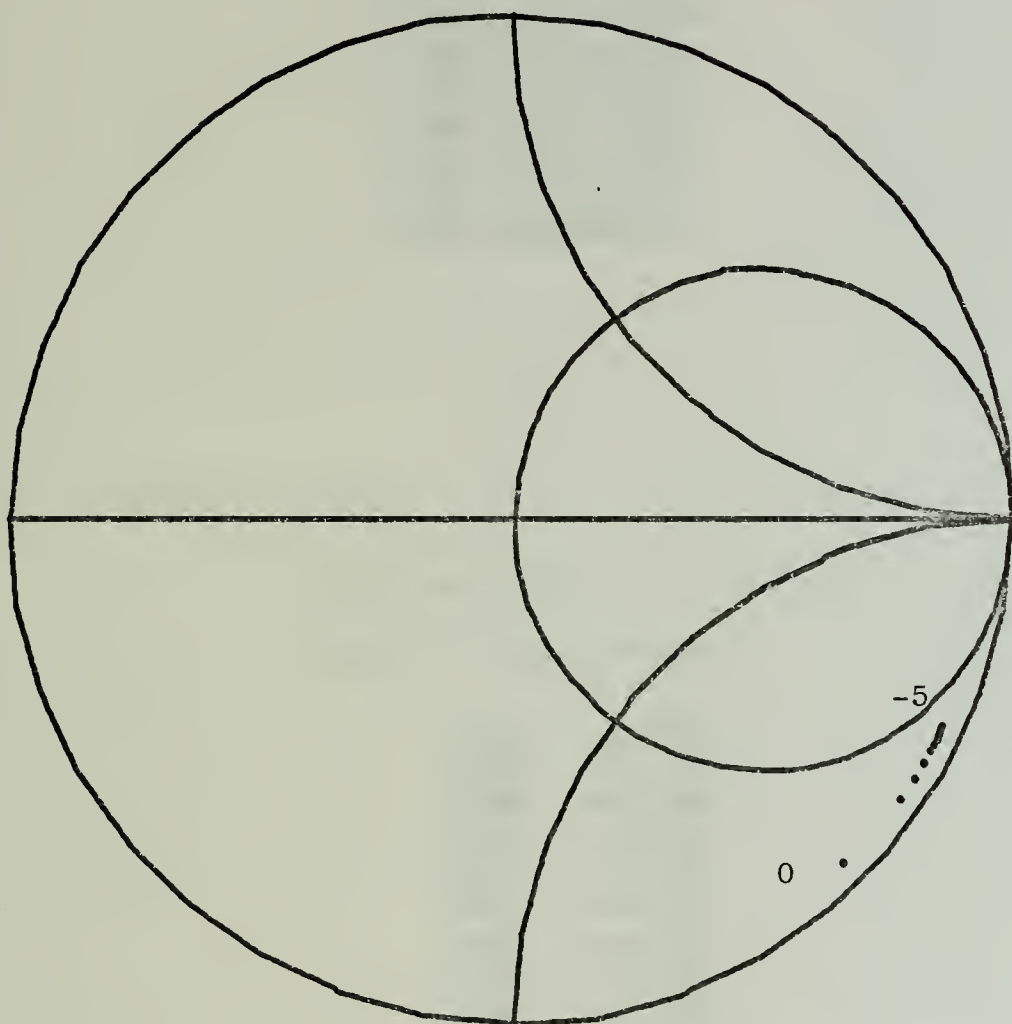


Figure 11a

Frequency in Hz

1.0017000000E09
 1.0017012500E09
 1.0017025000E09
 1.0017037500E09
 1.0017050000E09
 1.0017062500E09
 1.0017075000E09
 1.0017087500E09
 1.0017100000E09
 1.0017112500E09
 1.0017125000E09
 1.0017137500E09
 1.0017150000E09
 1.0017162500E09

Real and Imaginary Parts of
 Normalized Impedance.

.180	-2.378
.239	-3.138
.302	-3.481
.349	-3.727
.381	-3.871
.413	-4.107
.440	-4.252
.467	-4.381
.488	-4.442
.508	-4.538
.518	-4.613

Figure 11b

Depletion Capacitance Versus Reverse Bias Voltage for
Schottky Diode.

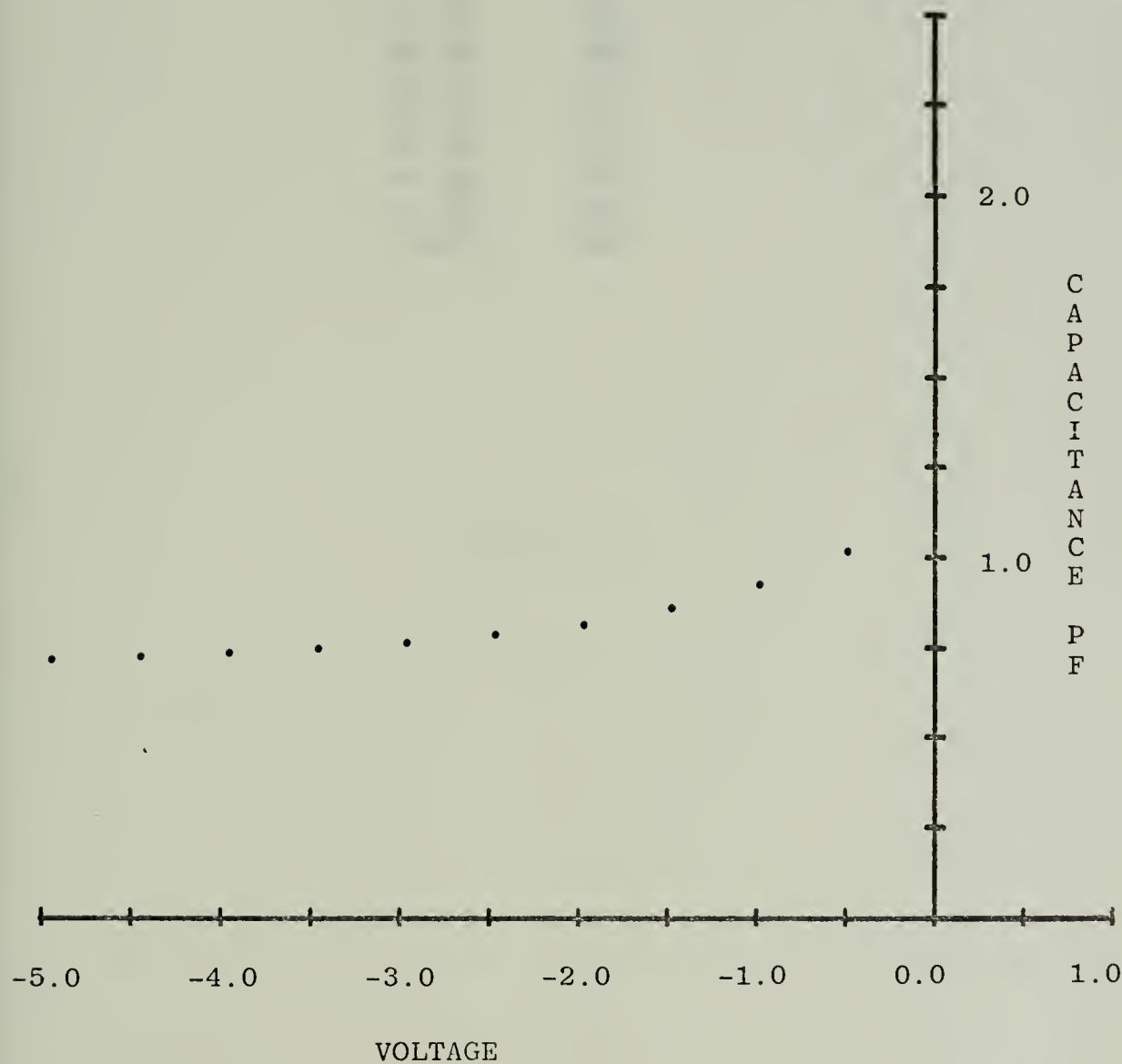


Figure 11c

VOLTS	PICOFARADS
0.00	1.33
-0.50	1.01
-1.00	.81
-1.50	.65
-2.00	.60
-2.50	.77
-3.00	.74
-3.50	.72
-4.00	.71
-4.50	.69
-5.00	.68

Figure 11d

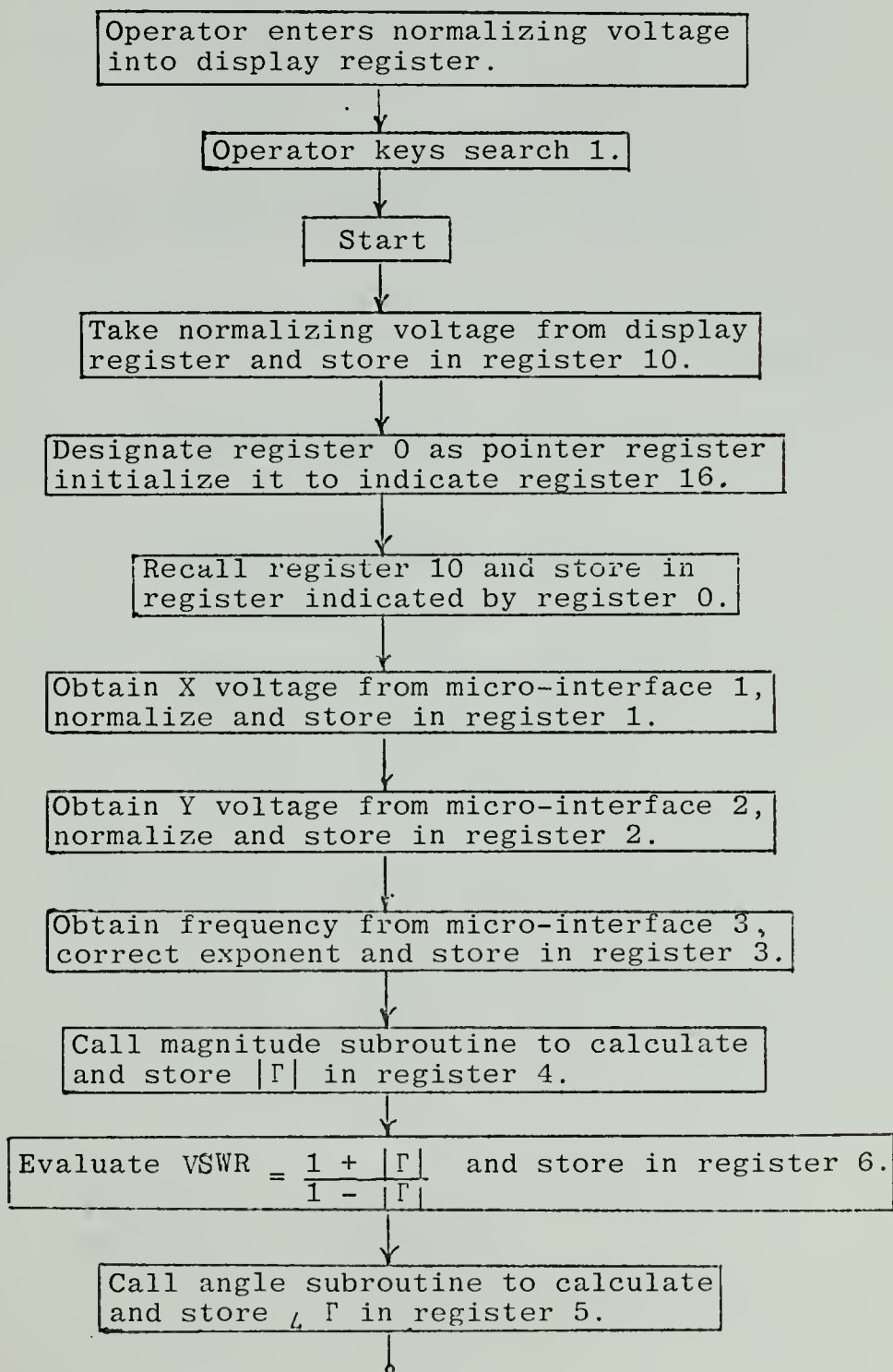
VI. CONCLUSIONS

The feasibility of calculator-aided microwave network analysis has been demonstrated. Data reduction program implementation requires more than casual familiarity with the programmable calculator.

VII. RECOMMENDATIONS

A digital to analog interface from the calculator to the sweep oscillator should be acquired. This would allow frequency selection under program control, thus making the analyzer-calculator system fully automatic.

APPENDIX A: S_{11}/S_{22} -PRINTING FLOWCHART



Relocate frequency, VSWR, $\text{Re } \Gamma(x)$, $\text{Im } \Gamma(y)$, $|\Gamma|$, and $\angle \Gamma$ in registers 17, 18, 19, 20, 21, and 22 respectively by storing indirectly through pointer register 0.

Recall x from register 1 and store in register 6.

Store $1 + x$ in register 1.

Call magnitude subroutine to evaluate and store $|(1 + x) + j \cdot y|$ in register 4.

Call angle subroutine to evaluate and store $\angle \{(1 + x) + j \cdot y\}$ in register 5.

Recall register 4 and store in register 7.

Recall register 5 and store in register 8.

Store $1 - x$ in register 1.

Store $-y$ in register 2.

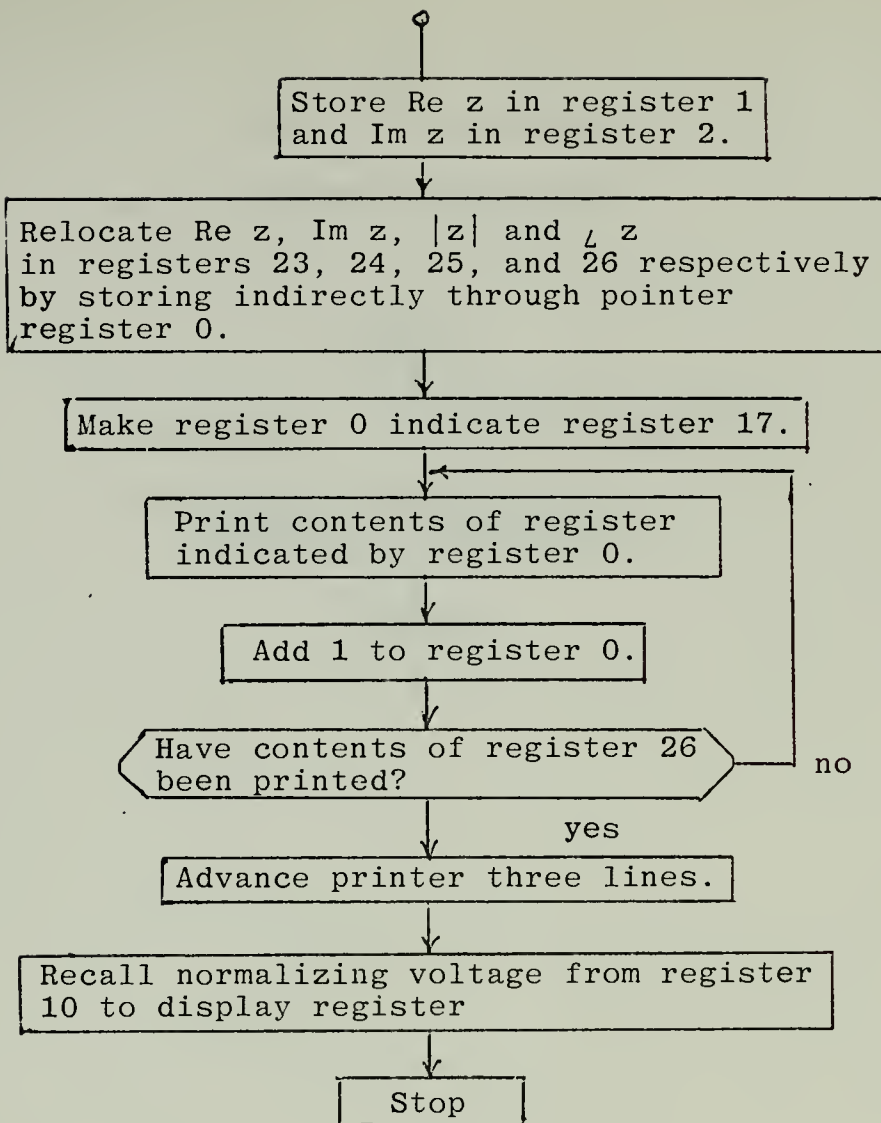
Call magnitude subroutine to evaluate and store $|(1 - x) - j \cdot y|$ in register 4.

Call angle subroutine to evaluate and store $\angle \{(1 - x) - j \cdot y\}$ in register 5.

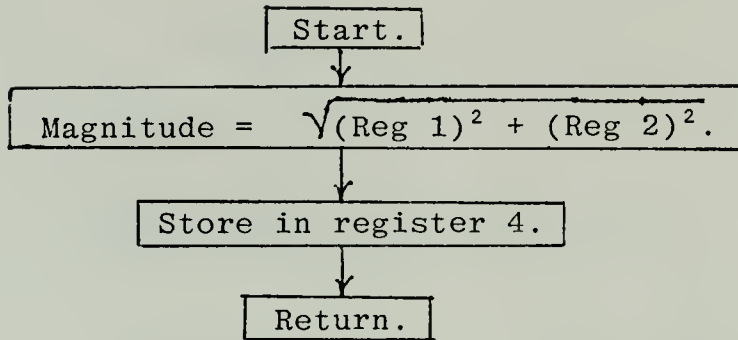
Evaluate $|z| = \frac{\text{Register 7}}{\text{Register 4}}$ and store in register 4.

Evaluate $\angle z = \text{Register 8} - \text{Register 5}$ and store in register 5.

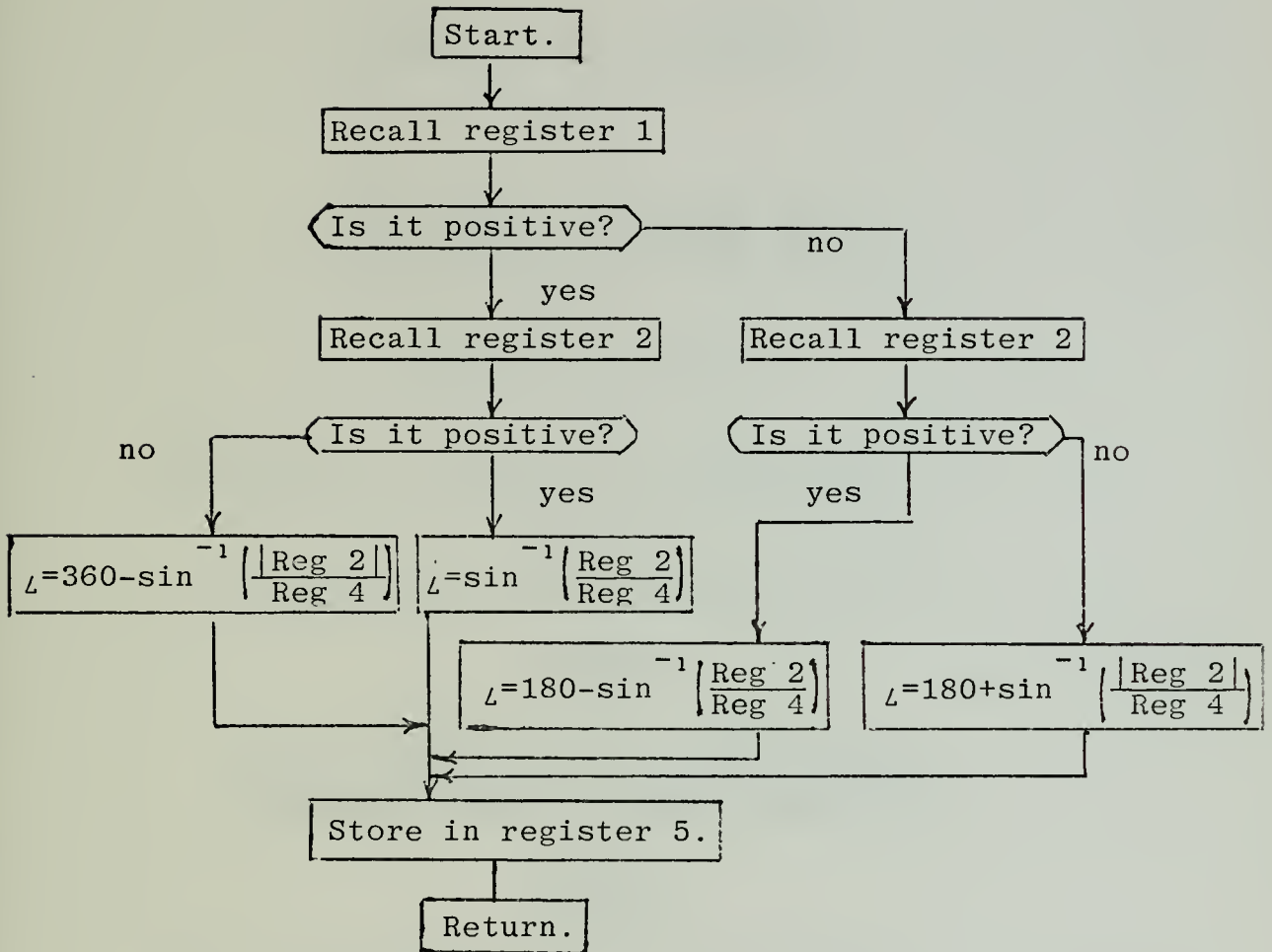
Evaluate $z = |z| \{\cos \angle z + j \cdot \sin \angle z\}$



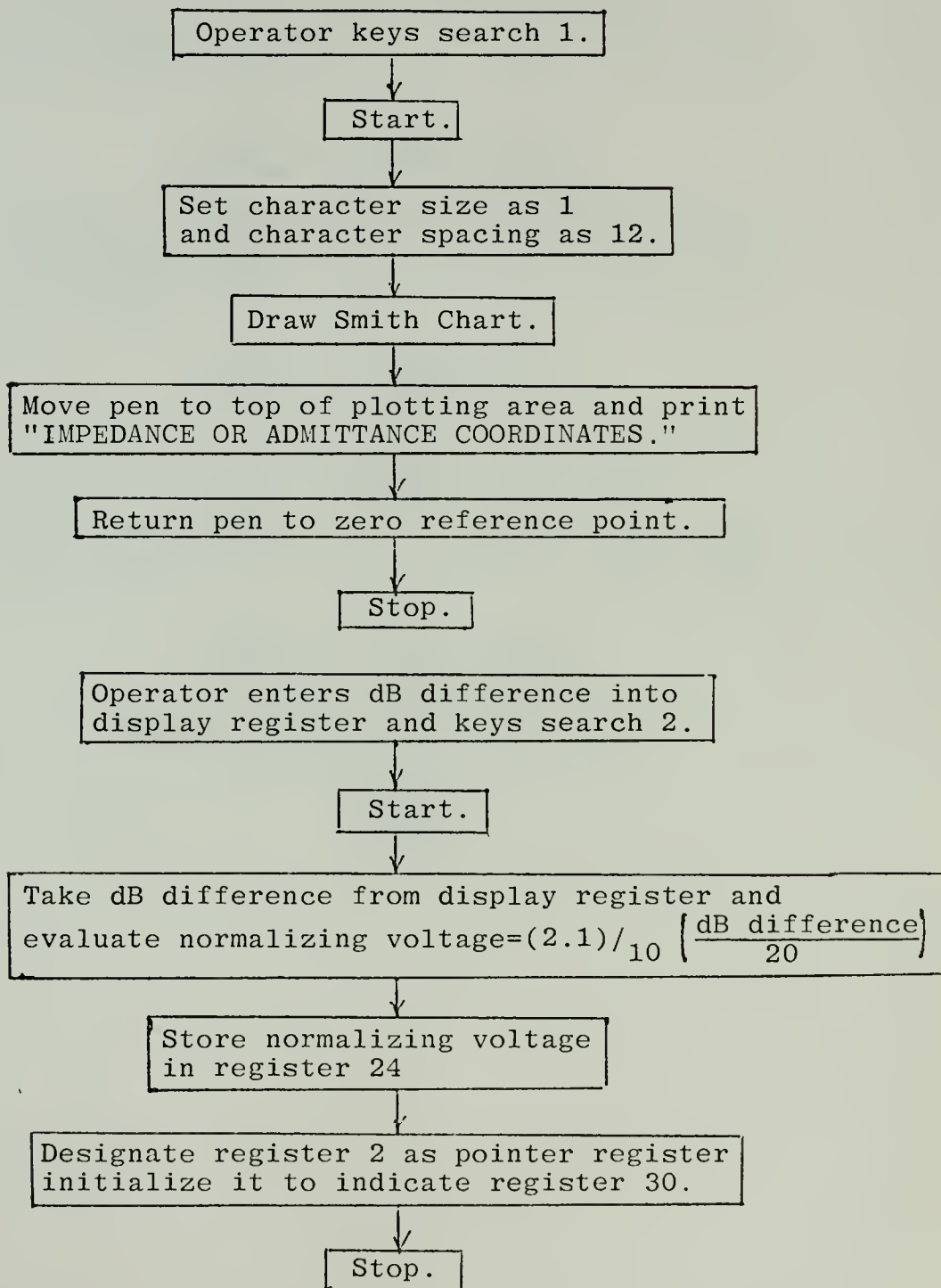
MAGNITUDE SUBROUTINE

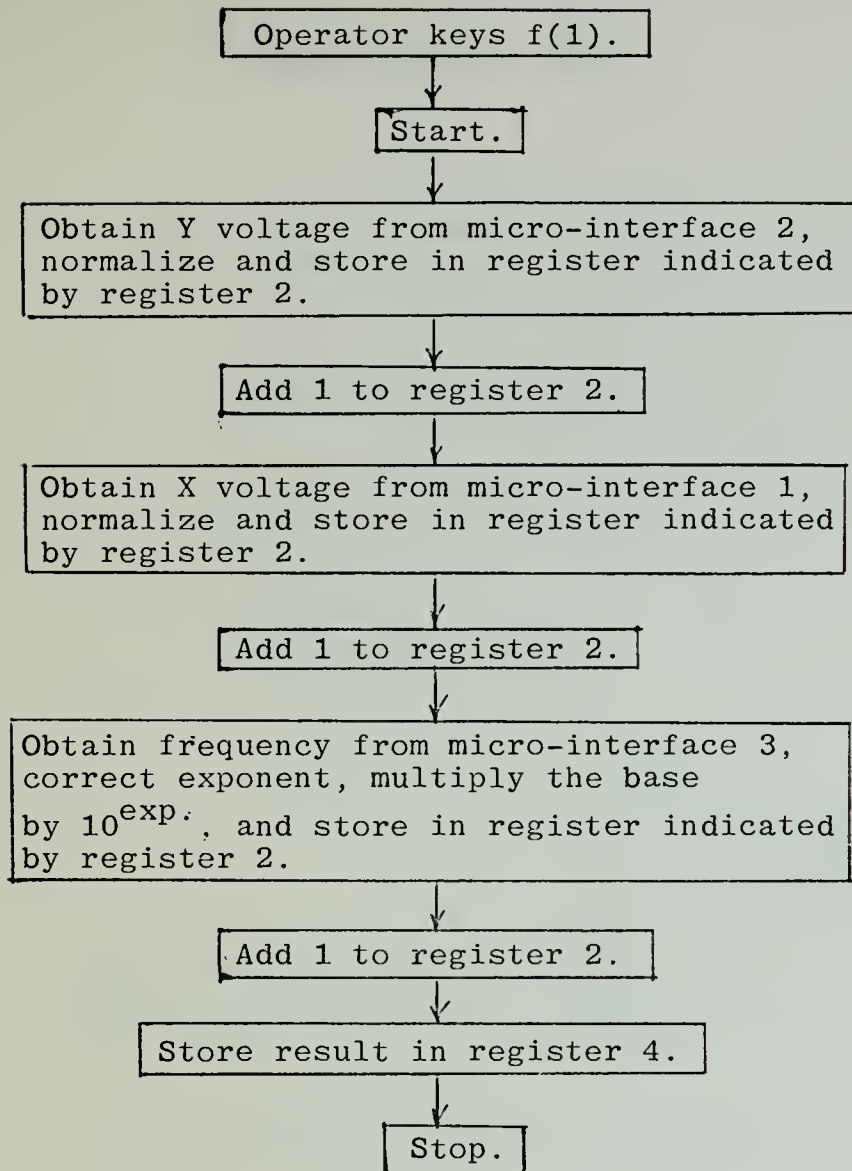


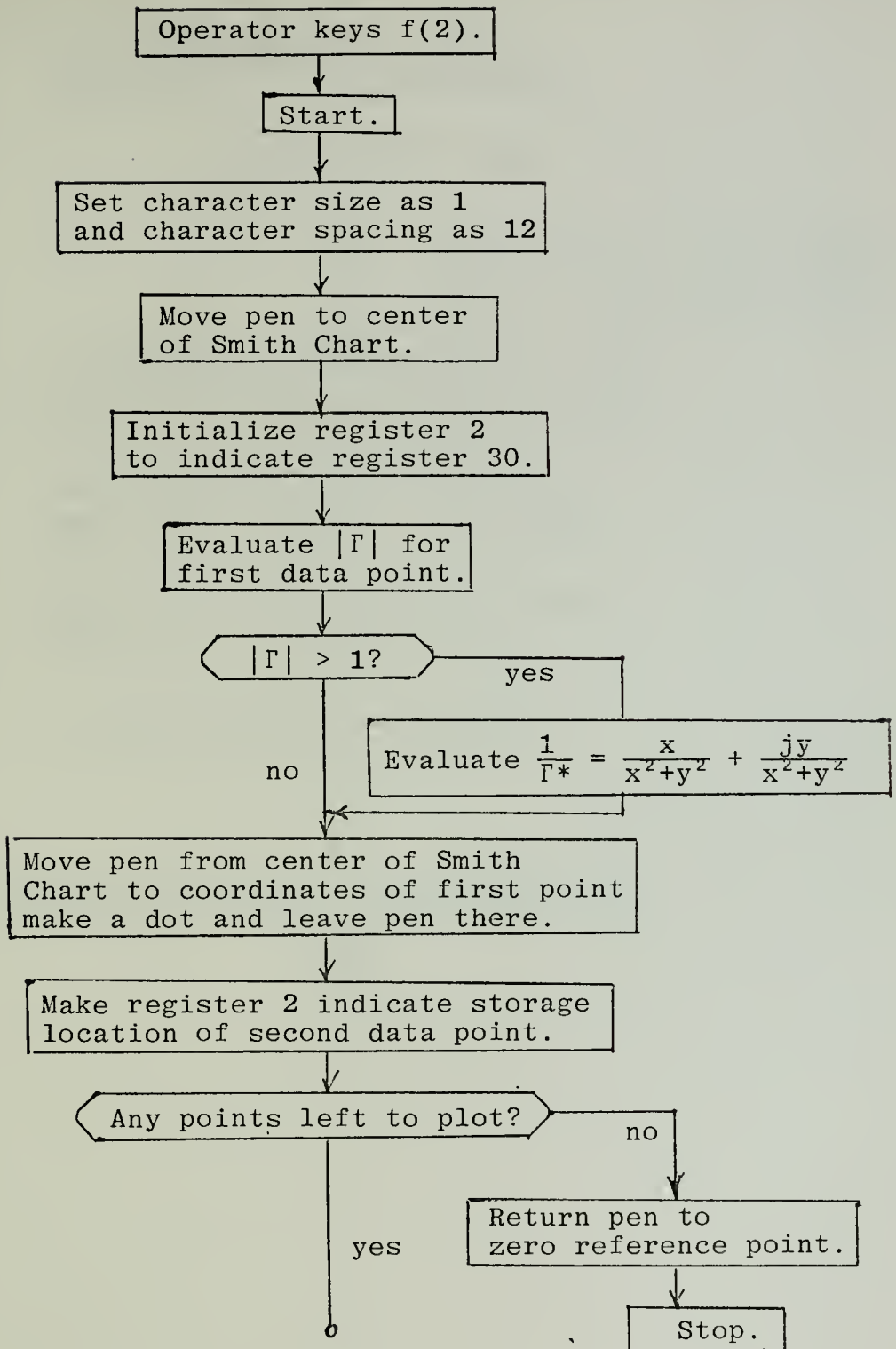
ANGLE SUBROUTINE

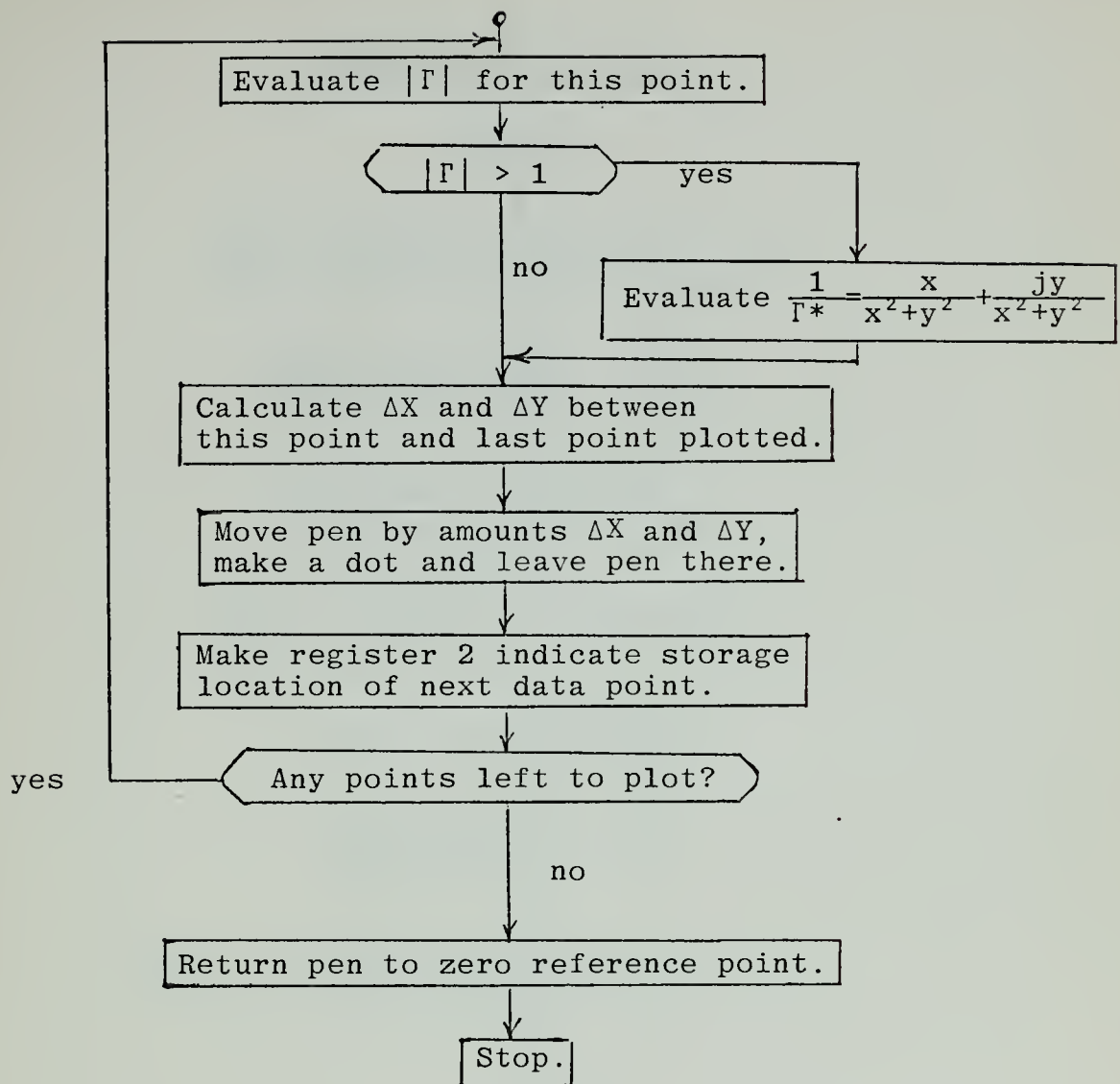


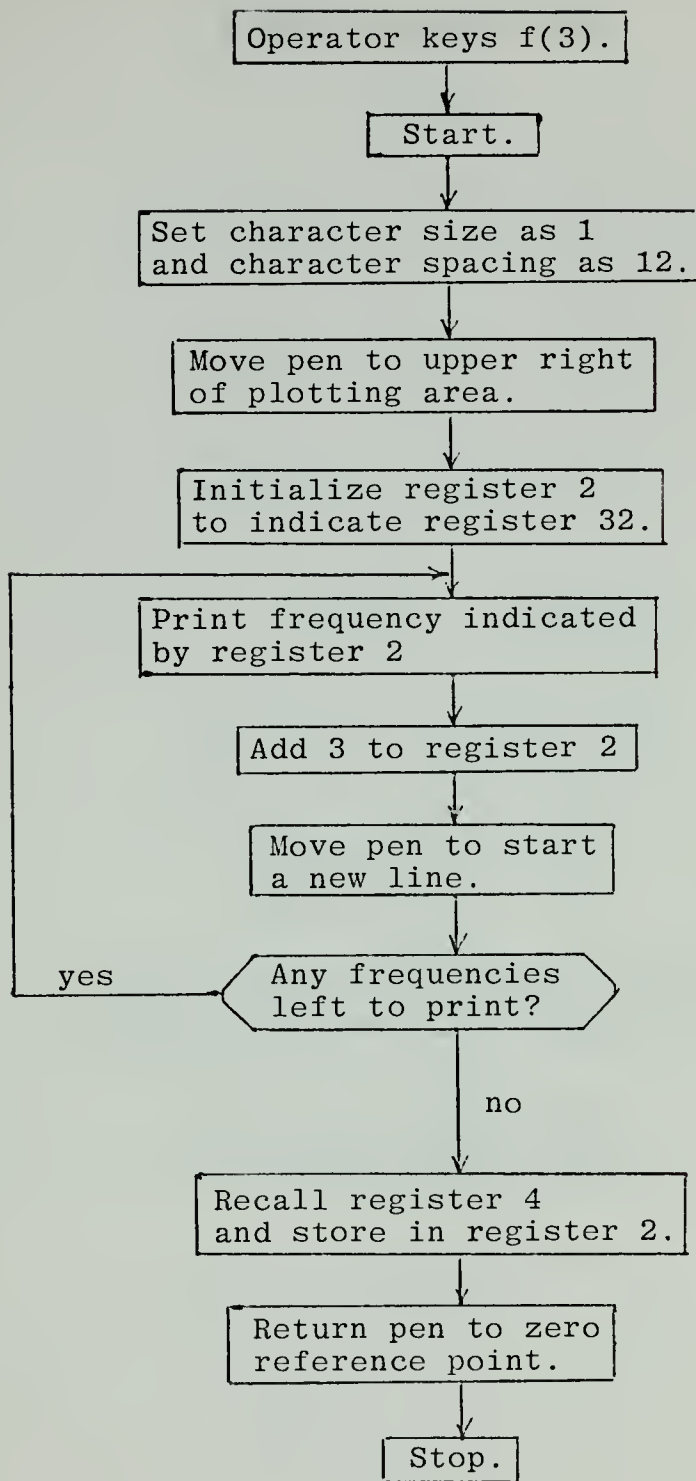
APPENDIX B: SMITH CHART-PLOTTING AND LISTING FLOWCHART

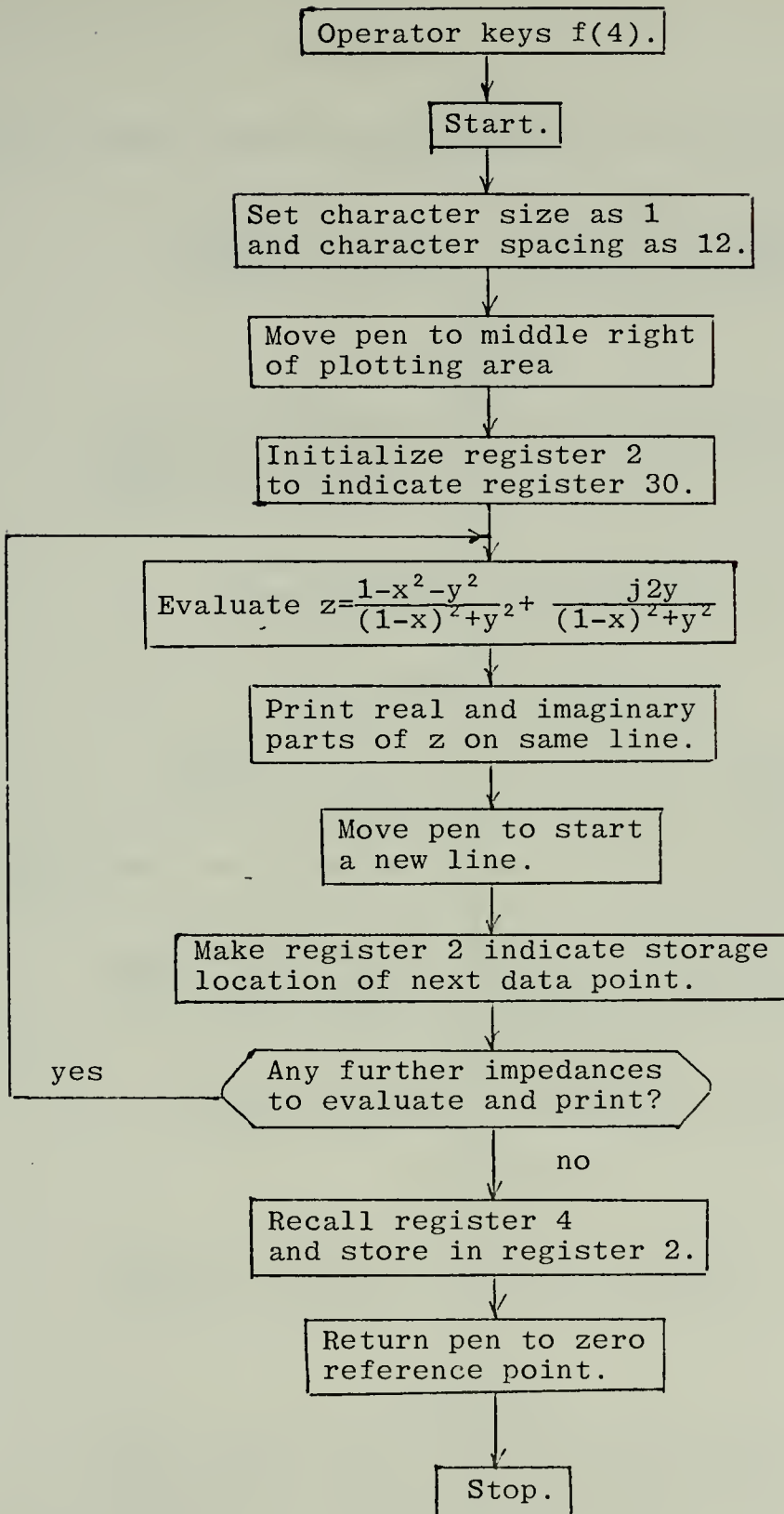






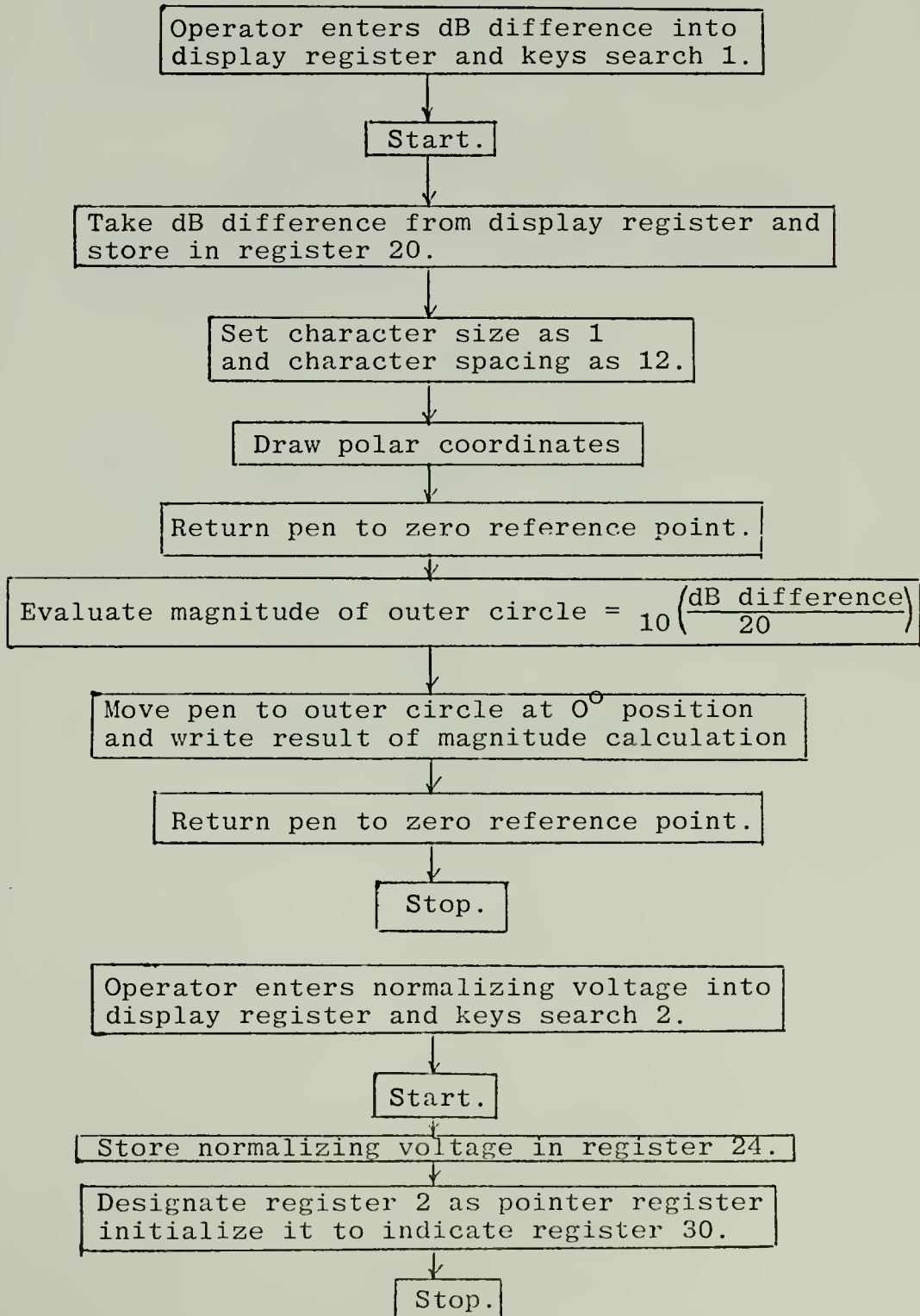


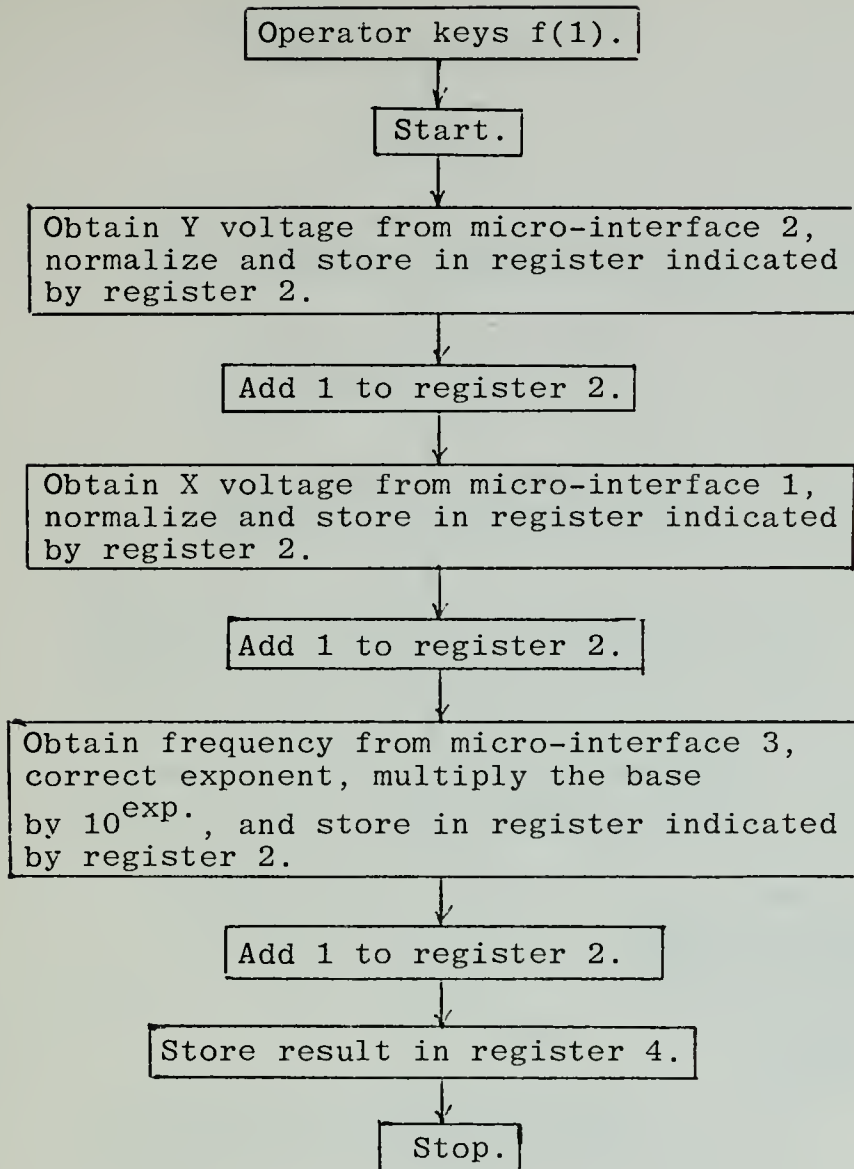


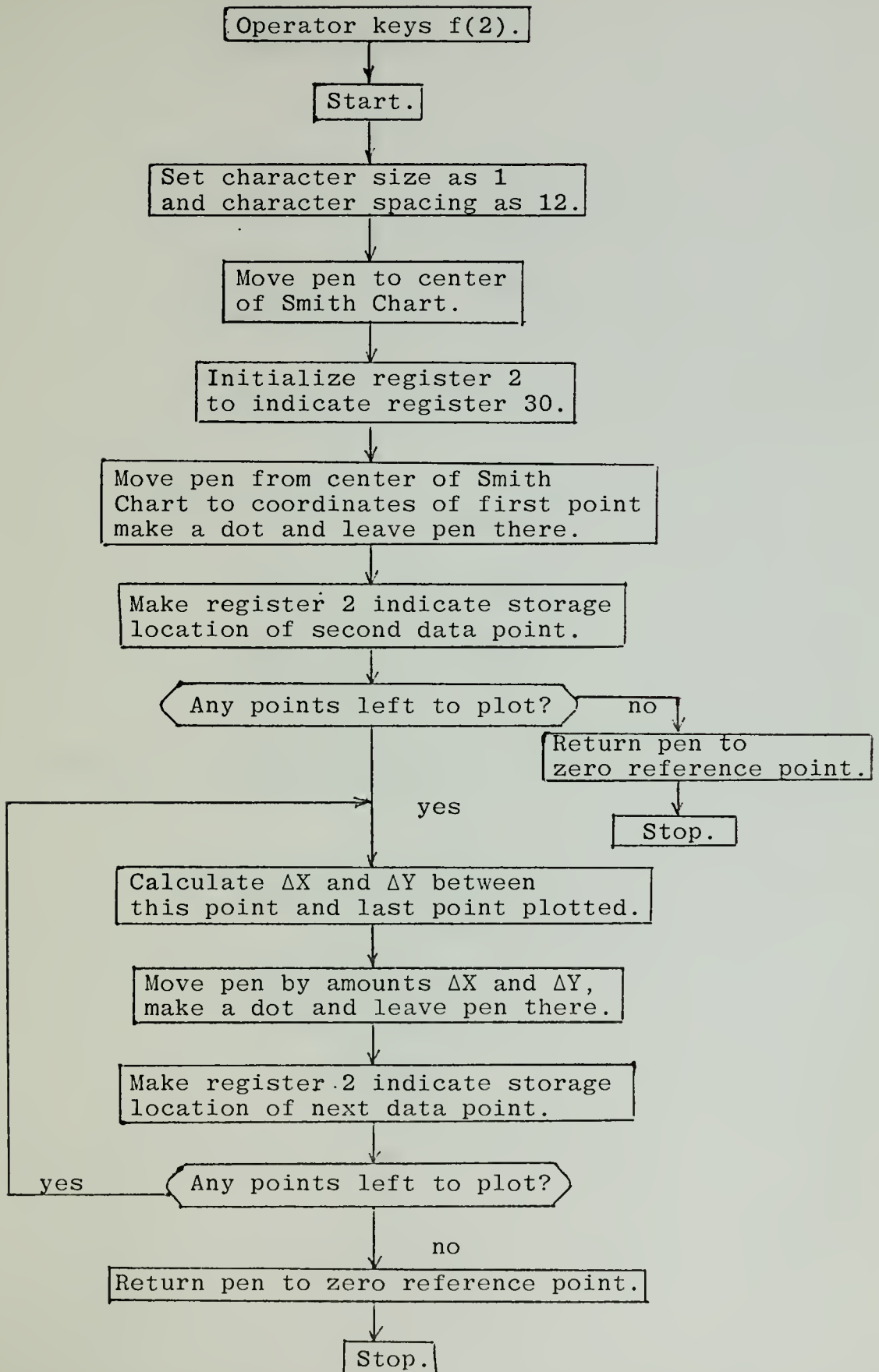


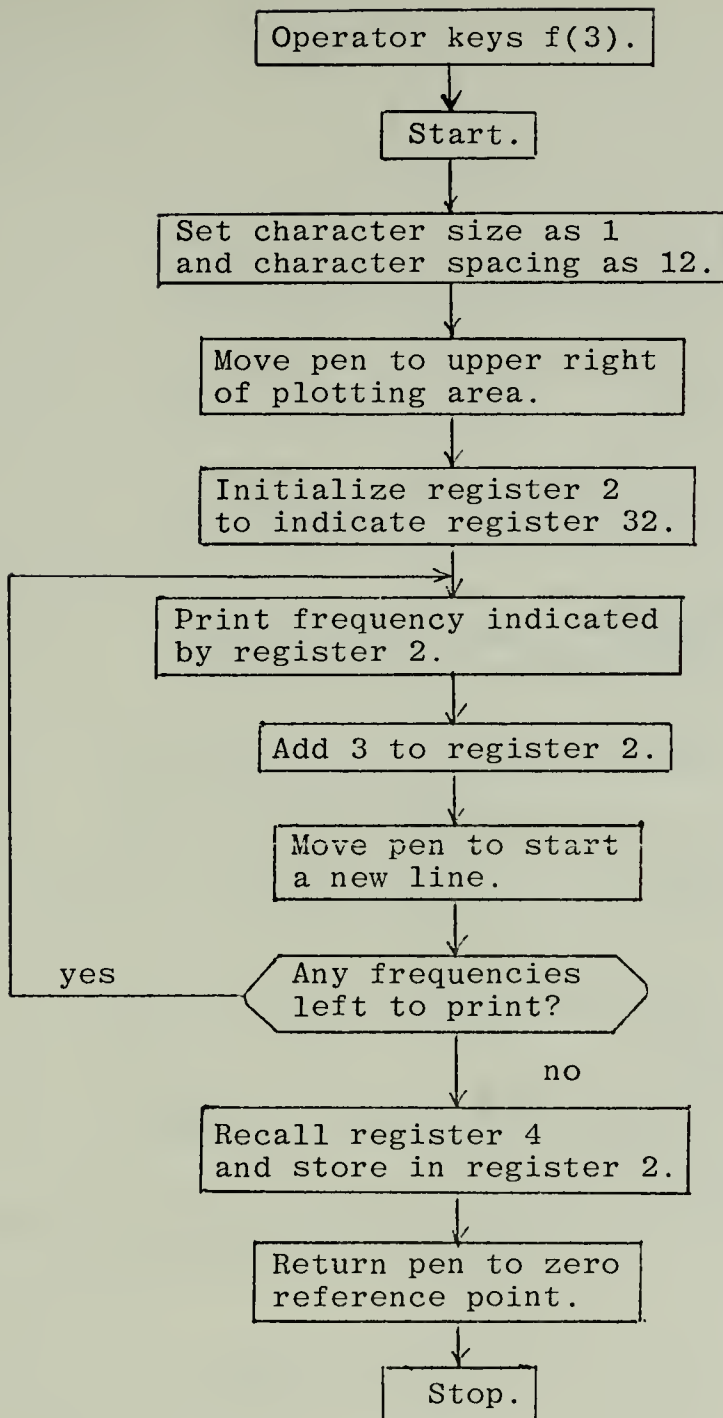
APPENDIX C

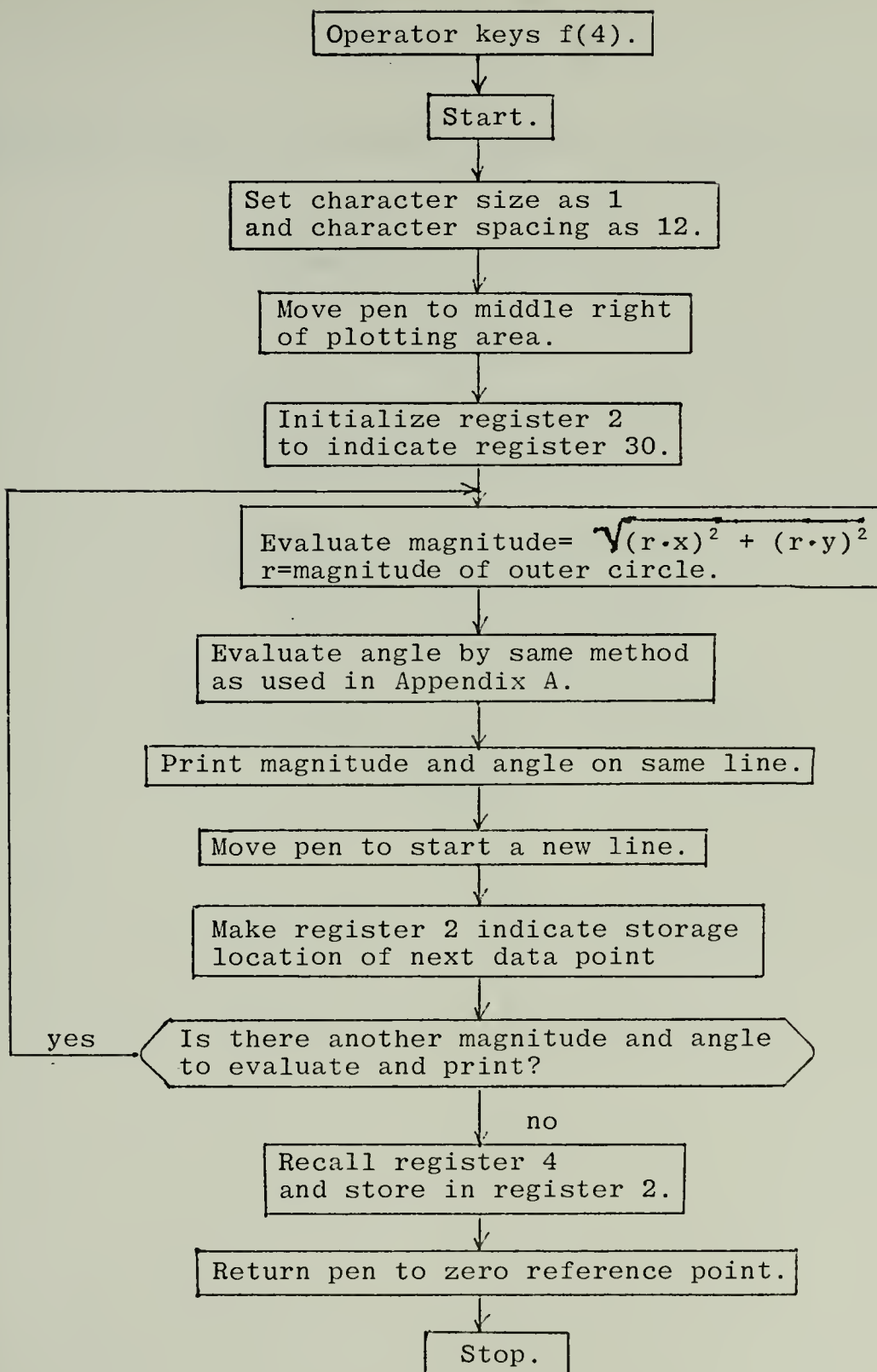
S_{12}/S_{21} POLAR COORDINATES-PLOTTING AND LISTING FLOWCHART



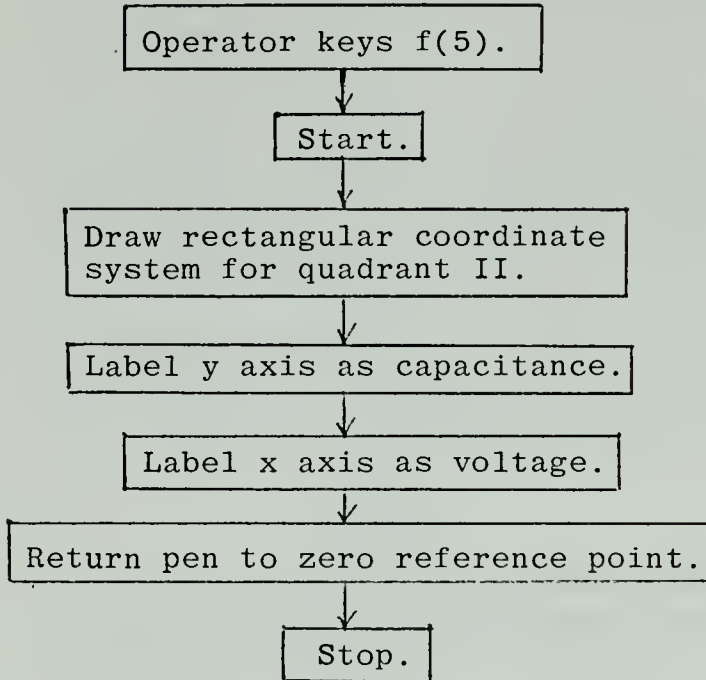


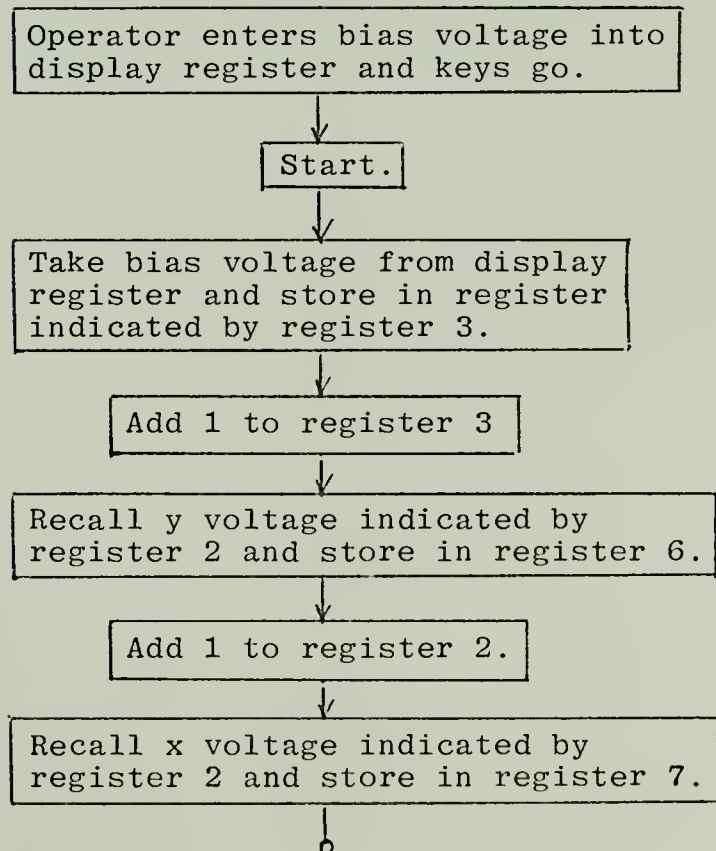
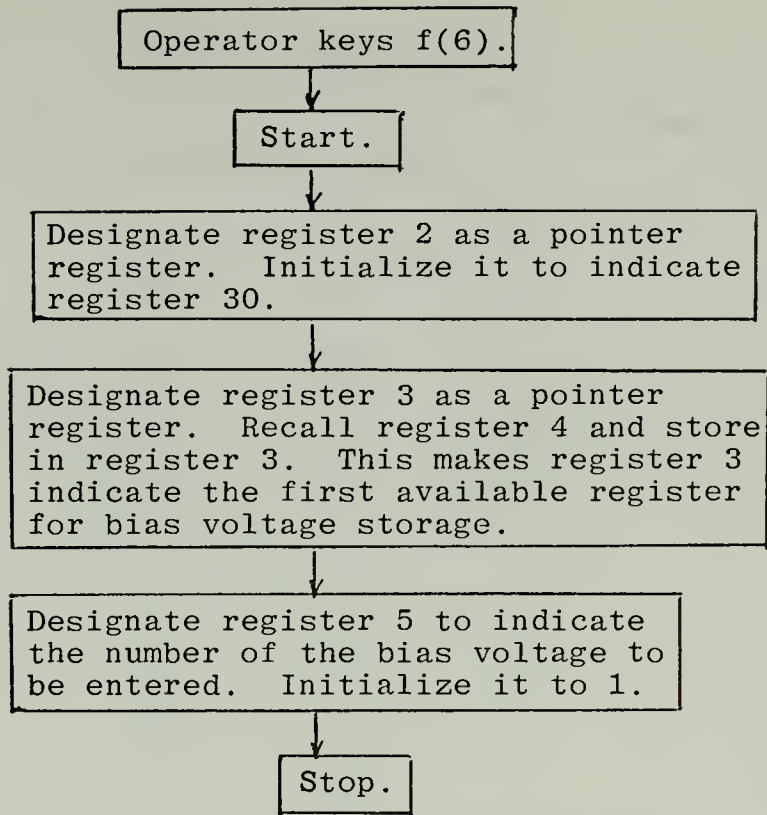


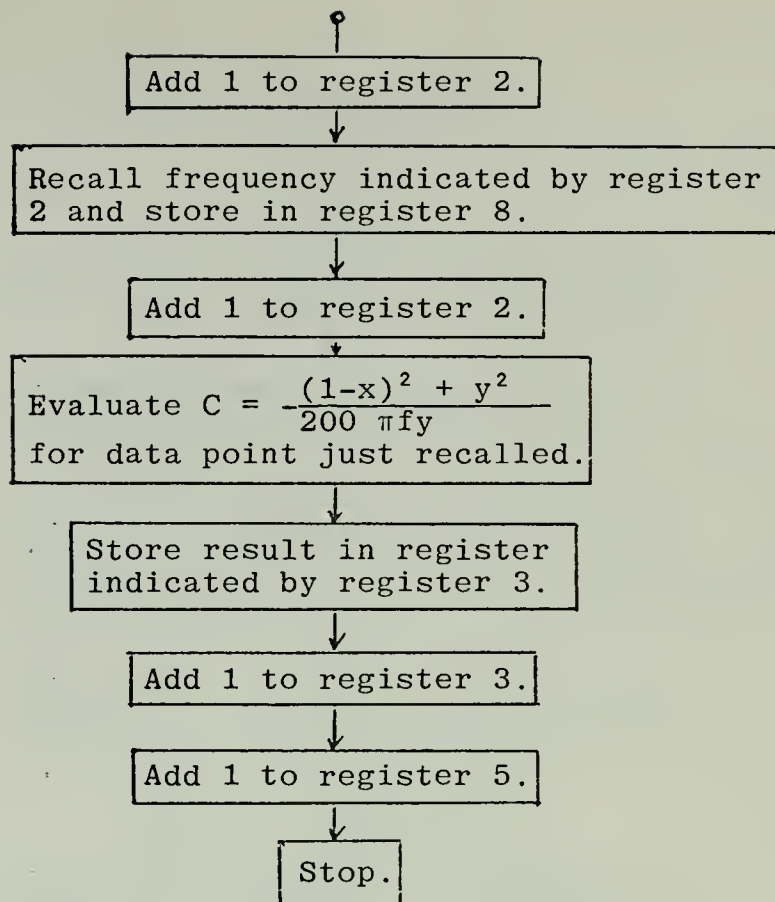


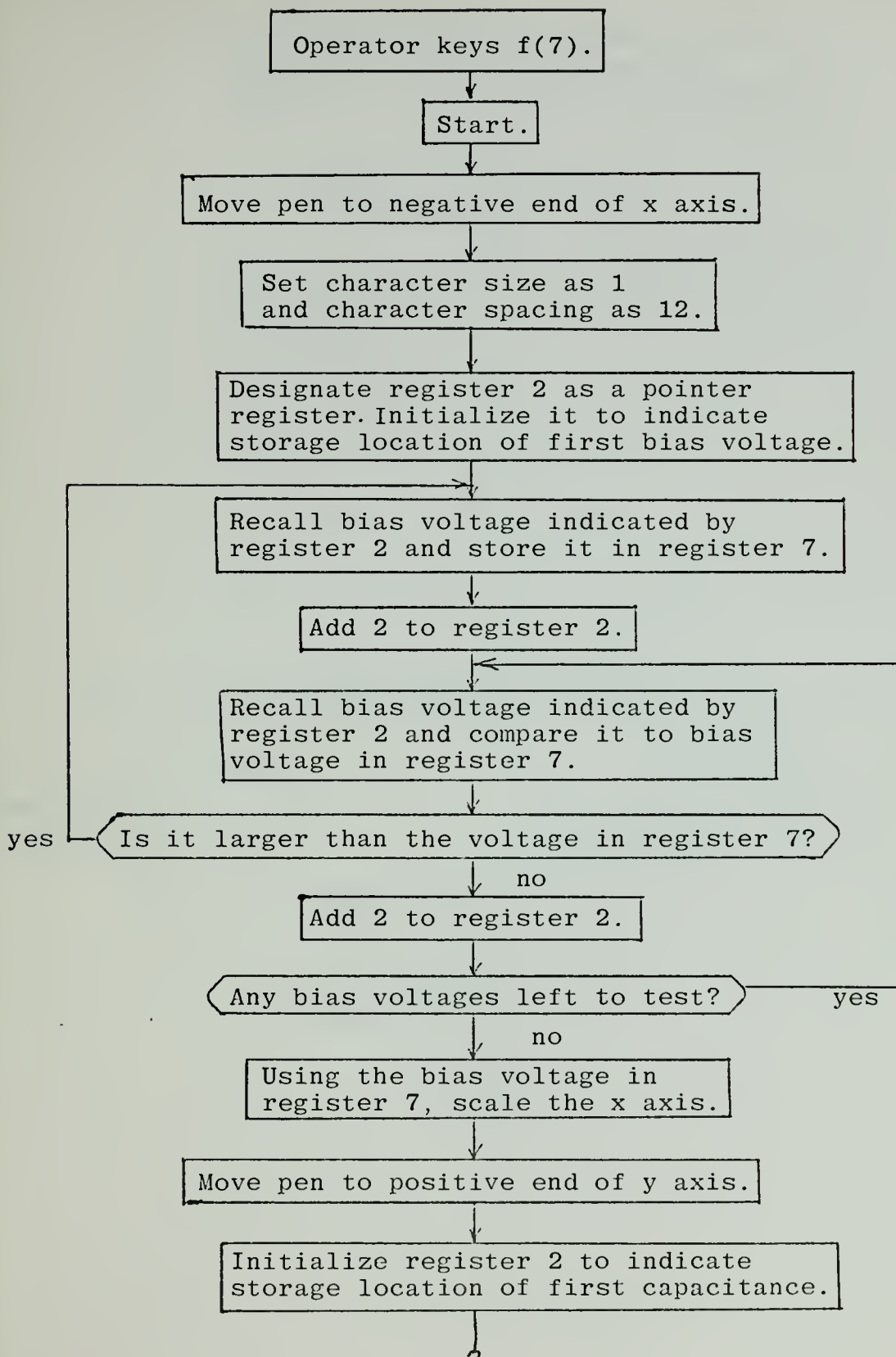


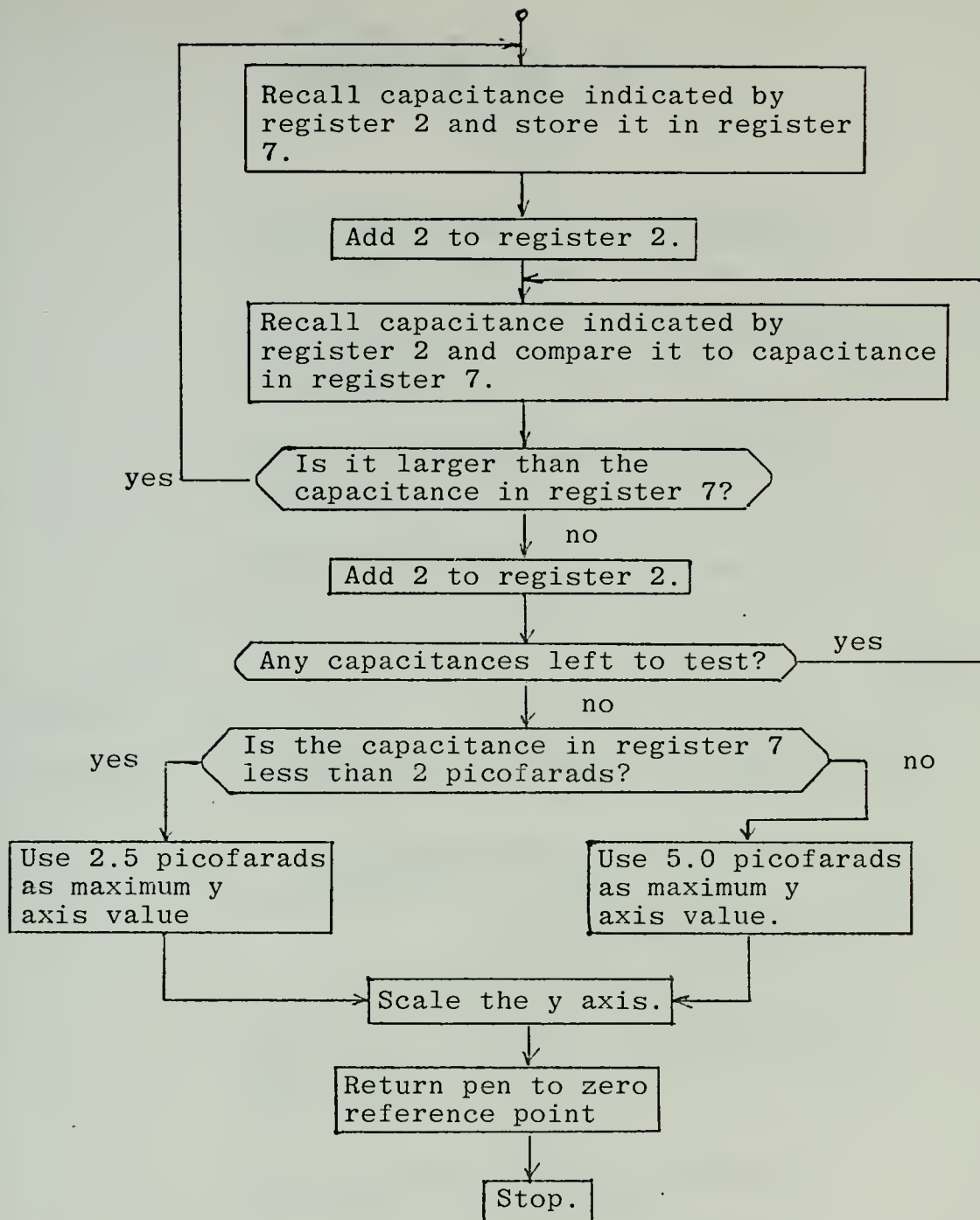
APPENDIX D
SCHOTTKY BARRIER CAPACITANCE-PLOTTING AND LISTING FLOWCHART

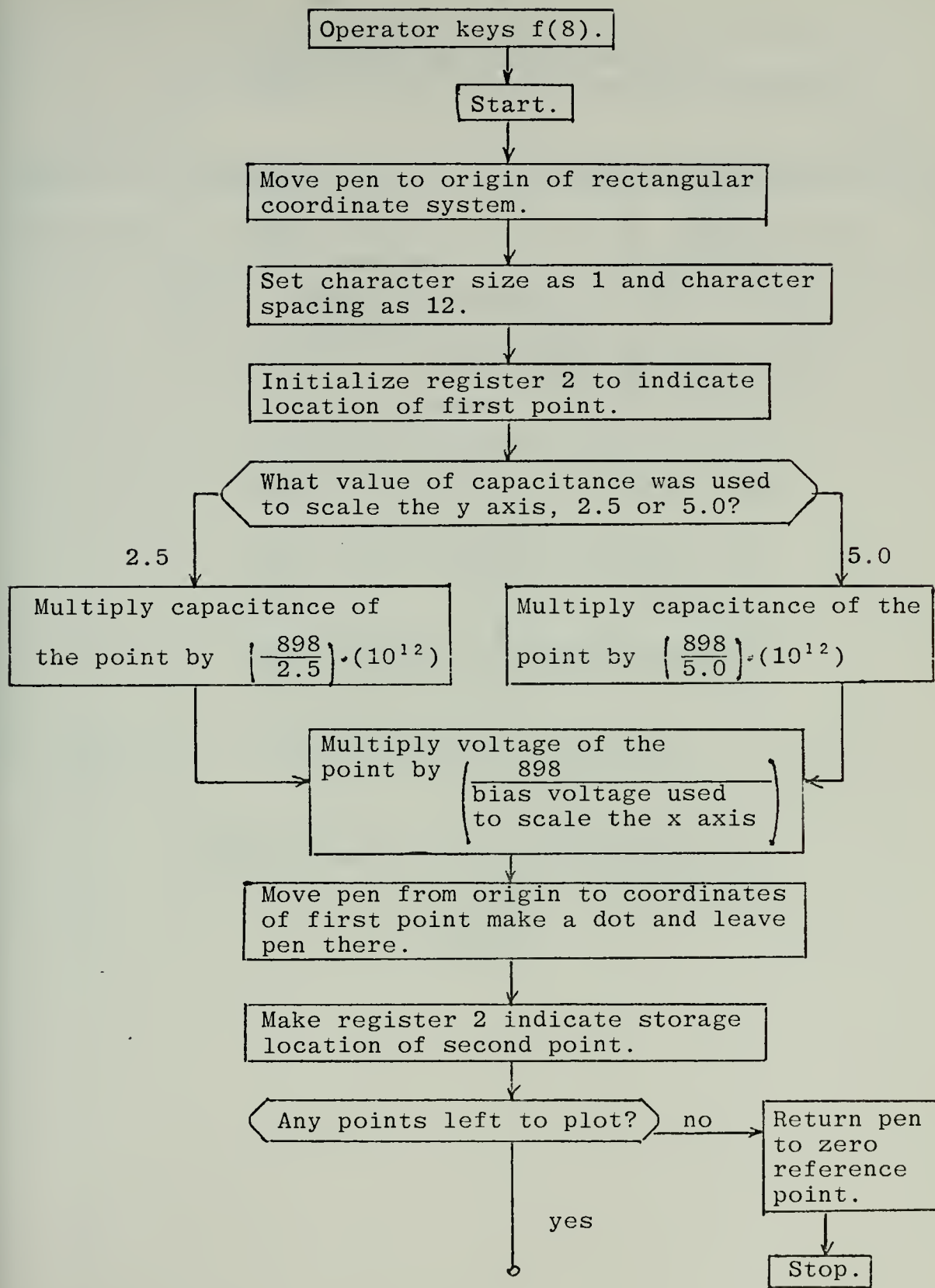


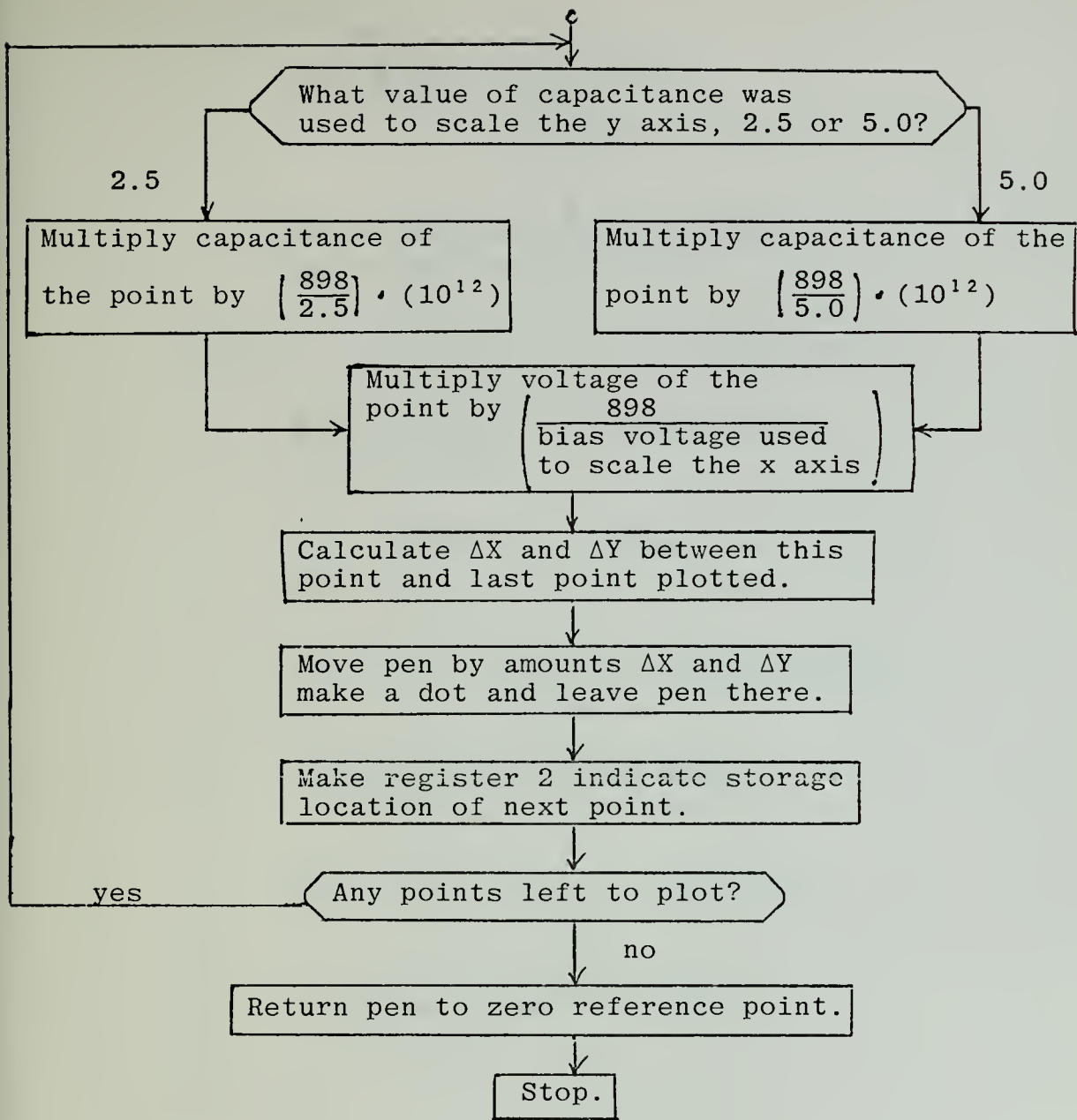


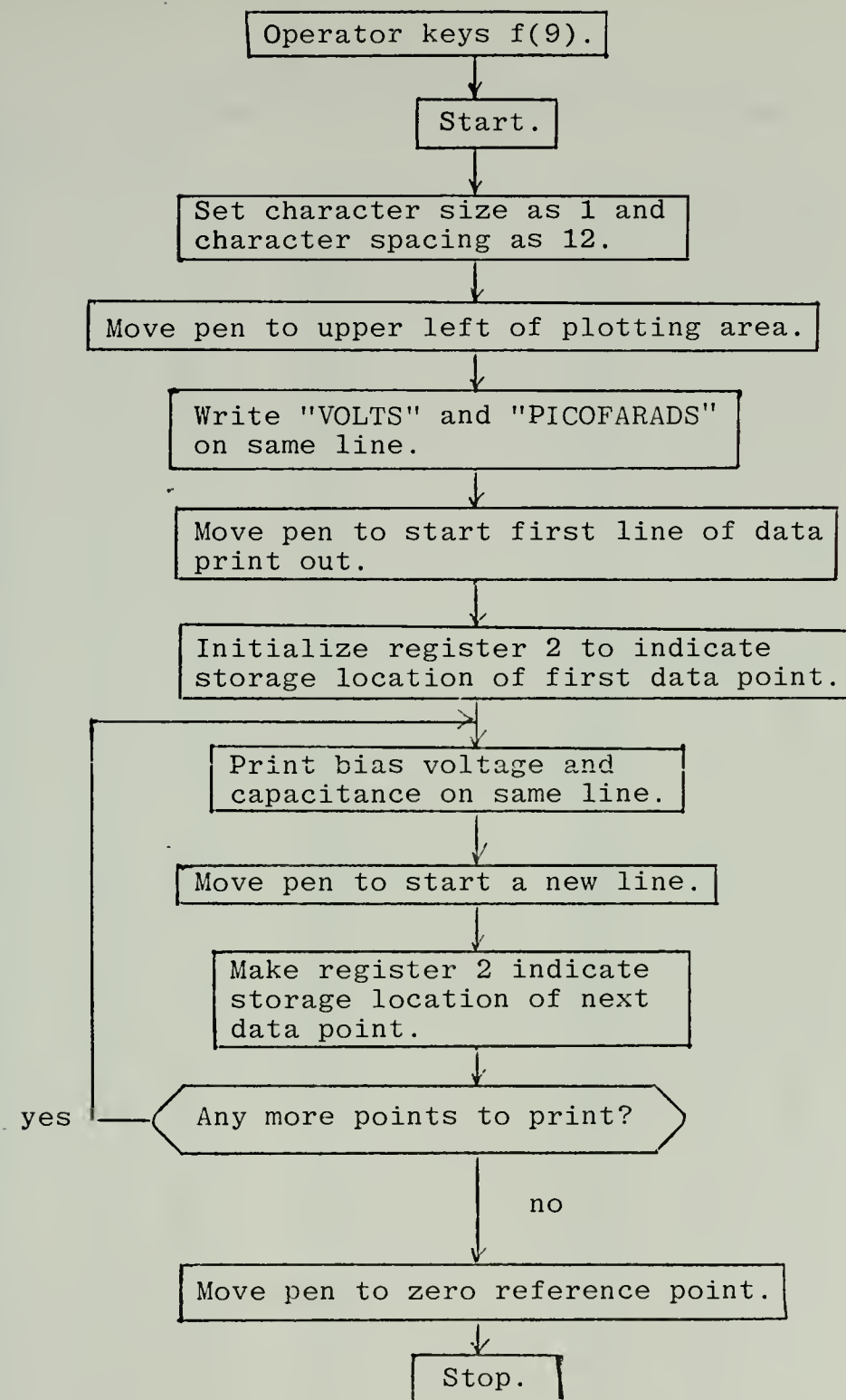












APPENDIX E: S_{11}/S_{22} -PRINTING PROGRAM

Verify = 3177

0000	09	00	*	M	0040	09	15	*	RI
0001	00	01	E 1		0041	09	00	*	M
0002	06	10	SI10		0042	10	02	f 2	
0003	00	01	E 1		0043	07	01	RE 1	
0004	00	06	E 6		0044	08	12	*	x ²
0005	06	00	SI 0		0045	06	14	SI14	
0006	07	10	RE10		0046	07	02	RE 2	
0007	15	11	D11		0047	08	12	*	x ²
0008	06	00	SI 0		0048	02	14	+14	
0009	10	01	f 1		0049	08	13	*	$\sqrt{x}$
0010	10	02	f 2		0050	06	04	SI 4	
0011	10	00	f 0		0051	09	15	*	RI
0012	10	03	f 3		0052	09	00	*	M
0013	10	04	f 4		0053	10	03	f 3	
0014	10	07	f 7		0054	07	01	RE 1	
0015	10	08	f 8		0055	08	05	*	J ₊
0016	10	10	f10		0056	03	00	*	S
0017	10	11	f11		0057	00	02	E 2	
0018	09	03	*	SP	0058	07	02	RE 2	
0019	09	00	*	M	0059	06	14	SI14	
0020	10	01	f 1		0060	08	05	*	J ₊
0021	15	13	D13		0061	08	00	*	S
0022	07	01	RE 1		0062	00	03	E 3	
0023	06	01	SI 1		0063	07	04	RE 4	
0024	15	11	D11		0064	05	14	÷14	
0025	07	00	RE 0		0065	09	06	*	S'
0026	05	01	÷ 1		0066	06	05	SI 5	
0027	15	13	D13		0067	09	15	*	RI
0028	07	02	RE 2		0068	09	00	*	M
0029	06	02	SI 2		0069	00	02	E 2	
0030	15	11	D11		0070	07	02	RE 2	
0031	07	00	RE 0		0071	06	14	SI14	
0032	05	02	÷ 2		0072	08	05	*	J ₊
0033	15	13	D13		0073	08	00	*	S
0034	07	03	RE 3		0074	00	04	E 4	
0035	15	13	D13		0075	00	01	E 1	
0036	07	03	RE 3		0076	00	08	E 8	
0037	06	03	SI 3		0077	00	00	E 0	
0038	00	02	E 2		0078	06	05	SI 5	
0039	02	03	+ 3		0079	07	04	RE 4	

0080	05	14	÷14		0120	07	01	NE 1	
0081	09	06	*	S'	0121	10	05	f 5	
0082	03	05	-5		0122	10	06	f 6	
0083	09	15	*	RT	0123	07	02	NE 2	
0084	09	00	*	M	0124	10	05	f 5	
0085	00	03	E 3		0125	10	06	f 6	
0086	00	12	E 12		0126	07	04	NE 4	
0087	06	14	ST 14		0127	10	05	f 5	
0088	00	03	E 3		0128	10	06	f 6	
0089	00	06	E 6		0129	07	05	NE 5	
0090	00	00	E 0		0130	10	05	f 5	
0091	06	05	ST 5		0131	09	15	*	RT
0092	07	04	RE 4		0132	09	00	*	M
0093	05	14	÷14		0133	10	05	f 5	
0094	09	06	*	S'	0134	15	11	D 11	
0095	03	05	-5		0135	06	00	ST 0	
0096	09	15	*	RT	0136	09	15	*	RT
0097	09	00	*	M	0137	09	00	*	M
0098	00	04	E 4		0138	10	06	f 6	
0099	00	12	E 12		0139	00	01	E 1	
0100	06	14	ST 14		0140	02	00	+ 0	
0101	00	01	E 1		0141	09	15	*	RT
0102	00	08	E 8		0142	09	00	*	M
0103	00	00	E 0		0143	10	07	f 7	
0104	06	05	ST 5		0144	07	01	NE 1	
0105	07	04	RE 4		0145	06	06	ST 6	
0106	05	14	÷14		0146	00	01	E 1	
0107	09	06	*	S'	0147	02	01	+ 1	
0108	02	05	+5		0148	10	02	f 2	
0109	10	05	f 5		0149	10	03	f 3	
0110	09	15	*	RT	0150	07	04	RE 4	
0111	09	00	*	M	0151	06	07	ST 7	
0112	10	04	f 4		0152	07	05	NE 5	
0113	10	06	f 6		0153	06	08	ST 8	
0114	07	03	RE 3		0154	00	02	E 2	
0115	10	05	f 5		0155	04	06	x 6	
0116	10	06	f 6		0156	03	01	- 1	
0117	07	06	RE 6		0157	07	02	NE 2	
0118	10	05	f 5		0158	00	12	E 12	
0119	10	06	f 6		0159	06	02	ST 2	

0160	10	02	f 2	0200	10	05	f 5
0161	10	03	f 3	0201	10	06	f 6
0162	07	04	RE 4	0202	07	02	RE 2
0163	05	07	÷ 7	0203	10	05	f 5
0164	06	04	ST 4	0204	10	06	f 6
0165	07	05	RE 5	0205	07	04	RE 4
0166	03	08	- 8	0206	10	05	f 5
0167	06	05	ST 5	0207	10	06	f 6
0168	09	15	* RT	0208	07	05	RE 5
0169	09	00	* M	0209	10	05	f 5
0170	10	08	f 8	0210	09	15	* RT
0171	07	05	RE 5	0211	09	00	* M
0172	08	07	* CS	0212	10	11	f 11
0173	06	01	ST 1	0213	07	00	RE 0
0174	07	04	RE 4	0214	06	01	ST 1
0175	04	01	× 1	0215	00	01	E 1
0176	07	05	RE 5	0216	00	06	E 6
0177	08	05	* J	0217	06	00	ST 0
0178	10	09	f 9	0218	09	00	* M
0179	09	15	* RT	0219	00	05	E 5
0180	08	06	* SN	0220	10	06	f 6
0181	06	02	ST 2	0221	10	12	f 12
0182	07	04	RE 4	0222	07	01	RE 1
0183	04	02	× 2	0223	09	02	* α
0184	09	15	* RT	0224	08	04	* Jo
0185	09	00	* M	0225	08	00	* S
0186	10	09	f 9	0226	00	05	E 5
0187	00	12	E 12	0227	08	02	* W
0188	08	06	* SN	0228	06	15	ST 15
0189	06	02	ST 2	0229	08	02	* W
0190	00	01	E 1	0230	06	15	ST 15
0191	00	12	E 12	0231	08	02	* W
0192	04	02	× 2	0232	06	15	ST 15
0193	07	04	RE 4	0233	07	10	RE 10
0194	04	02	× 2	0234	09	15	* RT
0195	09	15	* RT	0235	09	00	* M
0196	09	00	* M	0236	10	12	f 12
0197	10	10	f 10	0237	15	11	D 11
0198	10	06	f 6	0238	07	00	RE 0
0199	07	01	RE 1	0239	08	02	* W

0240	06	04	ST 4	
0241	09	15	*	NT
0242	09	00	*	M
0243	10	00	f 0	
0244	07	04	RE 4	
0245	06	06	ST 6	
0246	06	07	ST 7	
0247	00	01	E 1	
0248	00	12	E 12	
0249	04	07	x 7	
0250	00	01	E 1	
0251	02	06	+ 6	
0252	00	01	E 1	
0253	02	07	+ 7	
0254	05	06	÷ 6	
0255	09	15	*	RT
0256	09	03	*	SP
0257	09	14	*	EP

APPENDIX F: SMITH CHART-PLOTTING AND LISTING PROGRAM

Verify = .6980

0000	09 00	* M	0040	06 07	ST 7
0001	00 01	E 1	0041	00 03	E 3
0002	00 00	E 0	0042	00 07	E 7
0003	06 00	ST 0	0043	00 00	E 0
0004	00 01	E 1	0044	06 08	ST 8
0005	06 01	ST 1	0045	00 00	E 0
0006	09 02	* α	0046	06 04	ST 4
0007	05 08	$\div 8$	0047	06 05	ST 5
0008	02 02	+ 2	0048	00 04	E 4
0009	00 01	E 1	0049	00 04	E 4
0010	00 02	E 2	0050	00 09	E 9
0011	06 01	ST 1	0051	06 06	ST 6
0012	09 02	* α	0052	00 00	E 0
0013	05 10	$\div 10$	0053	06 10	ST 10
0014	02 02	+ 2	0054	06 11	ST 11
0015	00 05	E 5	0055	09 00	* M
0016	00 04	E 4	0056	00 04	E 4
0017	00 07	E 7	0057	07 07	RE 7
0018	06 00	ST 0	0058	08 06	* SN
0019	00 05	E 5	0059	06 00	ST 0
0020	00 06	E 6	0060	07 03	RE 3
0021	00 03	E 3	0061	04 00	$\times 0$
0022	06 01	ST 1	0062	06 12	ST 12
0023	00 04	E 4	0063	07 07	RE 7
0024	00 04	E 4	0064	08 07	* W
0025	00 09	E 9	0065	06 01	ST 1
0026	06 03	ST 3	0066	07 03	RE 3
0027	09 02	* α	0067	04 01	$\times 1$
0028	05 11	$\div 11$	0068	06 13	ST 13
0029	05 03	$\div 3$	0069	07 05	RE 5
0030	02 02	+ 2	0070	03 00	- 0
0031	00 00	E 0	0071	07 06	RE 6
0032	06 00	ST 0	0072	03 01	- 1
0033	07 03	RE 3	0073	07 12	RE 12
0034	06 01	ST 1	0074	06 05	ST 5
0035	09 02	* α	0075	07 13	RE 13
0036	05 03	$\div 3$	0076	06 06	ST 6
0037	02 02	+ 2	0077	07 10	RE 10
0038	00 01	E 1	0078	02 00	+ 0
0039	00 00	E 0	0079	07 11	RE 11

0080	02	01	+1		0120	06	14	SI14
0081	09	02	*	α	0121	07	04	RE 4
0082	05	02	$\div 2$		0122	03	14	-14
0083	02	02	+2		0123	09	04	* J.
0084	07	00	RE 0		0124	08	00	* S
0085	06	14	SI14		0125	00	07	E 7
0086	09	12	*	I	0126	00	02	E 2
0087	03	14	-14		0127	00	02	E 2
0088	06	10	SI10		0128	00	04	E 4
0089	07	01	RE 1		0129	06	03	SI 3
0090	06	14	SI14		0130	00	01	E 1
0091	09	12	*	I	0131	00	00	E 0
0092	03	14	-14		0132	06	07	SI 7
0093	06	11	SI11		0133	00	00	E 0
0094	00	01	E 1		0134	06	05	SI 5
0095	00	00	E 0		0135	00	02	E 2
0096	02	07	+7		0136	00	02	E 2
0097	06	14	SI14		0137	00	04	E 4
0098	07	08	RE 8		0138	06	06	SI 6
0099	03	14	-14		0139	08	00	* S
0100	08	05	*	J.	0140	00	04	E 4
0101	08	00	*	S	0141	09	00	* M
0102	00	04	E 4		0142	00	05	E 5
0103	00	01	E 1		0143	00	04	E 4
0104	02	04	+4		0144	00	04	E 4
0105	00	02	E 2		0145	00	09	E 9
0106	06	14	SI14		0146	06	03	SI 3
0107	07	04	RE 4		0147	00	01	E 1
0108	03	14	-14		0148	00	00	E 0
0109	09	04	*	J.	0149	00	00	E 0
0110	08	00	*	S	0150	06	07	SI 7
0111	00	05	E 5		0151	00	01	E 1
0112	00	03	E 3		0152	00	09	E 9
0113	06	14	SI14		0153	00	00	E 0
0114	07	04	RE 4		0154	06	08	SI 8
0115	03	14	-14		0155	00	04	E 4
0116	09	04	*	J.	0156	00	04	E 4
0117	08	00	*	S	0157	00	09	E 9
0118	00	06	E 6		0158	06	05	SI 5
0119	00	04	E 4		0159	00	00	E 0

0160	06	06	ST6	0200	00	08	E8
0161	08	00	* S	0201	00	09	E9
0162	00	04	E4	0202	00	08	E6
0163	09	00	* M	0203	06	01	ST1
0164	00	06	E6	0204	09	02	* α
0165	00	08	E8	0205	05	02	$\div 2$
0166	00	09	E9	0206	02	02	+2
0167	00	08	E8	0207	00	05	E5
0168	06	00	ST0	0208	00	00	E0
0169	00	00	E0	0209	00	05	E5
0170	06	01	ST1	0210	06	00	ST0
0171	09	02	* α	0211	00	02	E2
0172	05	03	$\div 3$	0212	00	05	E5
0173	02	02	+2	0213	00	00	E0
0174	00	04	E4	0214	06	01	ST1
0175	00	04	E4	0215	09	02	* α
0176	00	09	E9	0216	05	03	$\div 3$
0177	06	03	ST3	0217	02	02	+2
0178	00	01	E1	0218	00	01	E1
0179	00	09	E9	0219	06	01	ST1
0180	00	00	E0	0220	09	02	* α
0181	06	07	ST7	0221	05	08	$\div 8$
0182	00	02	E2	0222	02	02	+2
0183	00	08	E8	0223	00	00	E0
0184	00	00	E0	0224	06	00	ST0
0185	06	08	ST8	0225	00	01	E1
0186	00	00	E0	0226	00	02	E2
0187	06	05	ST5	0227	06	01	ST1
0188	00	12	E12	0228	09	02	* α
0189	00	04	E4	0229	05	10	$\div 10$
0190	00	04	E4	0230	01	04	T4
0191	00	09	E9	0231	01	15	T15
0192	06	06	ST6	0232	00	05	E5
0193	08	00	* S	0233	02	05	+5
0194	00	04	E4	0234	02	13	+13
0195	09	00	* M	0235	01	12	T12
0196	00	07	E7	0236	02	06	+6
0197	00	00	E0	0237	02	12	+12
0198	06	00	ST0	0238	02	05	+5
0199	00	12	E12	0239	05	03	$\div 3$

0240	01	09	T9
0241	01	13	T13
0242	05	03	÷3
0243	01	12	T12
0244	02	13	+13
0245	01	15	T15
0246	01	04	T4
0247	02	07	+7
0248	02	07	+7
0249	01	12	T12
0250	02	06	+6
0251	02	12	+12
0252	02	05	+5
0253	05	03	÷3
0254	02	12	+12
0255	01	09	T9
0256	01	09	T9
0257	01	13	T13
0258	02	13	+13
0259	01	04	T4
0260	02	06	+6
0261	01	12	T12
0262	02	07	+7
0263	02	05	+5
0264	01	01	T1
0265	05	11	÷11
0266	02	02	+2
0267	09	03	* 8

0263	09	00	*	M
0269	00	02	E2	
0270	06	15	SI15	
0271	00	02	E2	
0272	00	10	E10	
0273	00	01	E1	
0274	06	14	SI14	
0275	00	02	E2	
0276	00	00	E0	
0277	05	15	÷15	
0278	09	11	*	M
0279	09	01	*	SI
0280	01	09	T9	
0281	05	14	÷14	
0282	09	01	*	SI
0283	01	08	T8	
0284	00	03	E3	
0285	00	00	E0	
0286	06	02	SI2	
0287	09	03	*	SP

0288	09	00	* M	0328	00	01	E 1
0289	10	01	f 1	0329	00	00	E 0
0290	15	13	D13	0330	04	15	x15
0291	07	02	RE 2	0331	07	14	RE14
0292	06	14	SI14	0332	08	04	* J6
0293	08	01	* RE	0333	08	00	* S
0294	01	03	T 8	0334	08	06	* J1
0295	05	14	÷14	0335	07	15	RE15
0296	15	11	D11	0336	15	11	D11
0297	06	02	SI 2	0337	06	02	SI 2
0298	00	01	E 1	0338	00	01	E 1
0299	02	02	+2	0339	02	02	+2
0300	15	13	D13	0340	06	04	SI 4
0301	07	01	RE 1	0341	09	15	* RT
0302	06	14	SI14				
0303	08	01	* RE				
0304	01	08	T 8				
0305	05	14	÷14				
0306	15	11	D11				
0307	06	02	SI 2				
0308	00	01	E 1				
0309	02	02	+2				
0310	15	13	D13				
0311	07	03	RE 3				
0312	15	13	D13				
0313	07	03	RE 3				
0314	06	14	SI14				
0315	09	02	* α				
0316	11	01	F 1				
0317	09	12	* I				
0318	06	15	SI15				
0319	09	02	* α				
0320	10	01	f 1				
0321	03	14	-14				
0322	00	02	E 2				
0323	02	14	+14				
0324	09	00	* M				
0325	08	06	* SN				
0326	00	01	E 1				
0327	03	14	-14				

0342	09	00	*	M	0382	11	02	F 2
0343	10	02	f 2		0383	08	05	* J.
0344	00	00	E 0		0384	11	03	F 3
0345	06	00	SI 0		0385	08	03	* G
0346	00	01	E 1		0386	07	05	RE 5
0347	06	01	SI 1		0387	06	00	SI 0
0348	09	02	*	α	0388	07	06	RE 6
0349	05	08	$\div 8$		0389	06	01	SI 1
0350	02	02	+ 2		0390	00	02	E 2
0351	00	01	E 1		0391	02	02	+ 2
0352	00	02	E 2		0392	09	02	* α
0353	06	01	SI 1		0393	05	03	$\div 3$
0354	09	02	*	α	0394	01	06	T 6
0355	05	10	$\div 10$		0395	02	02	+ 2
0356	02	02	+ 2		0396	10	10	f 10
0357	00	05	E 5		0397	07	04	RE 4
0358	00	04	E 4		0398	06	14	SI 14
0359	00	07	E 7		0399	07	02	RE 2
0360	06	00	SI 0		0400	03	14	- 14
0361	00	05	E 5		0401	08	04	* J.
0362	00	06	E 6		0402	08	00	* S
0363	00	03	E 3		0403	00	03	E 3
0364	06	01	SI 1		0404	09	02	* α
0365	00	03	E 3		0405	05	11	$\div 11$
0366	00	00	E 0		0406	02	02	+ 2
0367	06	02	SI 2		0407	09	03	* SP
0368	00	04	E 4		0408	09	00	* M
0369	00	04	E 4		0409	00	03	E 3
0370	00	09	E 9		0410	07	10	RE 10
0371	06	03	SI 3		0411	02	00	+ 0
0372	09	02	*	α	0412	07	11	RE 11
0373	05	11	$\div 11$		0413	02	01	+ 1
0374	05	03	$\div 3$		0414	07	00	RE 0
0375	02	02	+ 2		0415	00	12	E 12
0376	01	00	T 0		0416	06	00	SI 0
0377	01	01	T 1		0417	07	01	RE 1
0378	01	10	T 10		0418	00	12	E 12
0379	01	11	T 11		0419	06	01	SI 1
0380	11	01	F 1		0420	11	01	F 1
0381	06	05	*	J.	0421	08	05	* J.

0422	11	02	F 2	0462	00	12	E12
0423	08	05	* J ₄	0463	06	01	SI 1
0424	11	03	F 3	0464	09	02	* α
0425	03	03	* ω	0465	05	03	$\div 3$
0426	07	05	RE 5	0466	02	02	+ 2
0427	02	00	+ 0	0467	07	07	RE 7
0428	07	06	RE 6	0468	06	00	SI 0
0429	02	01	+ 1	0469	07	08	RE 8
0430	09	02	* α	0470	06	01	SI 1
0431	05	03	$\div 3$	0471	09	15	* RT
0432	01	06	T 6				
0433	02	02	+ 2				
0434	10	10	f10				
0435	07	05	RE 5				
0436	06	00	SI 0				
0437	07	06	RE 6				
0438	06	01	SI 1				
0439	00	02	E 2				
0440	02	02	+ 2				
0441	07	04	RE 4				
0442	06	14	SI 14				
0443	07	02	RE 2				
0444	03	14	-14				
0445	08	04	* J ₆				
0446	08	00	* S				
0447	00	03	E 3				
0448	09	02	* α				
0449	05	11	$\div 11$				
0450	02	02	+ 2				
0451	09	03	* SP				
0452	09	00	* M				
0453	10	10	f10				
0454	07	00	RE 0				
0455	06	07	SI 7				
0456	07	01	RE 1				
0457	06	08	SI 8				
0458	00	00	E 0				
0459	06	00	SI 0				
0460	00	01	E 1				
0461	00	02	E 2				

0472	09 00	*	M	0512	00 03	E3
0473	10 03	f3		0513	00 02	E2
0474	09 02	*	α	0514	06 02	ST2
0475	05 11	$\div 11$		0515	09 00	* M
0476	02 02	+2		0516	08 07	* CS
0477	00 09	E9		0517	15 11	D11
0478	00 09	E9		0518	07 02	RE2
0479	00 09	E9		0519	15 02	D2
0480	06 00	ST0		0520	01 01	T1
0481	00 09	E9		0521	00 03	E3
0482	00 09	E9		0522	02 02	+2
0483	00 09	E9		0523	00 02	E2
0484	06 01	ST1		0524	00 00	E0
0485	06 01	ST1		0525	00 12	E12
0486	09 02	*	α	0526	06 00	ST0
0487	05 03	$\div 3$		0527	00 01	E1
0488	02 02	+2		0528	00 09	E9
0489	00 00	E0		0529	00 02	E2
0490	06 00	ST0		0530	00 12	E12
0491	00 01	E1		0531	06 01	ST1
0492	06 01	ST1		0532	09 02	* α
0493	09 02	*	α	0533	05 03	$\div 3$
0494	05 08	$\div 8$		0534	02 02	+2
0495	02 02	+2		0535	07 02	RE2
0496	00 00	E0		0536	06 00	ST0
0497	06 00	ST0		0537	07 04	RE4
0498	00 01	E1		0538	09 02	* α
0499	00 02	E2		0539	08 05	* J
0500	06 01	ST1		0540	08 00	* S
0501	09 02	*	α	0541	08 07	* CS
0502	05 10	$\div 10$		0542	07 04	RE4
0503	02 02	+2		0543	06 02	ST2
0504	00 00	E0		0544	09 02	* α
0505	06 00	ST0		0545	05 11	$\div 11$
0506	00 04	E4		0546	02 02	+2
0507	00 00	E0		0547	09 15	* RT
0508	06 01	ST1				
0509	09 02	*	α			
0510	05 03	$\div 3$				
0511	02 02	+2				

0548	09	00	*	M	0588	00	00	E 0	
0549	10	04	f 4		0589	06	02	SI 2	
0550	09	02	*	α	0590	09	00	*	M
0551	05	11	$\div 11$		0591	09	07	*	C'
0552	02	02	+ 2		0592	15	11	D 11	
0553	00	05	E 5		0593	07	02	RE 2	
0554	00	01	E 1		0594	06	05	SI 5	
0555	00	00	E 0		0595	00	01	E 1	
0556	06	00	SI 0		0596	02	02	+ 2	
0557	00	09	E 9		0597	15	11	D 11	
0558	00	09	E 9		0598	07	02	RE 2	
0559	00	09	E 9		0599	06	06	SI 6	
0560	06	01	SI 1		0600	07	05	RE 5	
0561	09	02	*	α	0601	08	12	*	x^2
0562	05	03	$\div 3$		0602	06	14	SI 14	
0563	02	02	+ 2		0603	07	06	RE 6	
0564	00	00	E 0		0604	00	12	E 12	
0565	06	00	SI 0		0605	06	15	SI 15	
0566	00	04	E 4		0606	00	01	E 1	
0567	00	00	E 0		0607	02	15	+ 15	
0568	06	01	SI 1		0608	08	12	*	x^2
0569	09	02	*	α	0609	02	14	+ 14	
0570	05	03	$\div 3$		0610	06	07	SI 7	
0571	02	02	+ 2		0611	07	05	RE 5	
0572	00	00	E 0		0612	08	12	*	x^2
0573	06	00	SI 0		0613	00	12	E 12	
0574	00	01	E 1		0614	06	14	SI 14	
0575	06	01	SI 1		0615	07	06	RE 6	
0576	09	02	*	α	0616	08	12	*	x^2
0577	05	08	$\div 8$		0617	00	12	E 12	
0578	02	02	+ 2		0618	02	14	+ 14	
0579	00	00	E 0		0619	00	01	E 1	
0580	06	00	SI 0		0620	02	14	+ 14	
0581	00	01	E 1		0621	07	07	RE 7	
0582	00	02	E 2		0622	05	14	$\div 14$	
0583	06	01	SI 1		0623	06	08	SI 8	
0584	09	02	*	α	0624	07	05	RE 5	
0585	05	10	$\div 10$		0625	06	14	SI 14	
0586	02	02	+ 2		0626	00	02	E 2	
0587	00	03	E 3		0627	04	14	$\times 14$	

0628	07	07	RE 7	0668	09	02	*	α	
0629	05	14	$\div 14$	0669	05	11	$\div 11$		
0630	06	09	SI 9	0670	02	02	+ 2		
0631	07	08	RE 8	0671	09	15	*	RT	
0632	15	02	D 2	0672	09	00	*	M	
0633	03	03	- 3	0673	11	01	F 1		
0634	00	00	E 0	0674	15	11	D 11		
0635	06	00	SI 0	0675	07	02	RE 2		
0636	00	01	E 1	0676	08	12	*	x^2	
0637	00	02	E 2	0677	06	14	SI 14		
0638	06	01	SI 1	0678	00	01	E 1		
0639	09	02	*	α	0679	02	02	+ 2	
0640	05	03	$\div 3$	0680	15	11	D 11		
0641	02	02	+ 2	0681	07	02	RE 2		
0642	07	09	RE 9	0682	08	12	*	x^2	
0643	15	02	D 2	0683	02	14	+ 14		
0644	03	03	- 3	0684	08	13	*	$\sqrt{x}$	
0645	00	02	E 2	0685	06	15	SI 15		
0646	00	00	E 0	0686	00	01	E 1		
0647	00	12	E 12	0687	03	15	- 15		
0648	06	00	SI 0	0688	09	15	*	RT	
0649	00	02	E 2	0689	09	00	*	M	
0650	00	00	E 0	0690	11	02	F 2		
0651	00	04	E 4	0691	00	01	E 1		
0652	00	12	E 12	0692	03	02	- 2		
0653	06	01	SI 1	0693	15	11	D 11		
0654	09	02	*	α	0694	07	02	RE 2	
0655	05	03	$\div 3$	0695	06	05	SI 5		
0656	02	02	+ 2	0696	08	01	*	RE	
0657	00	02	E 2	0697	01	08	T 8		
0658	02	02	+ 2	0698	04	05	$\times 5$		
0659	07	04	RE 4	0699	00	01	E 1		
0660	06	14	SI 14	0700	02	02	+ 2		
0661	07	02	RE 2	0701	15	11	D 11		
0662	03	14	- 14	0702	07	02	RE 2		
0663	08	04	*	J_0	0703	06	06	SI 6	
0664	08	00	*	S	0704	08	01	*	RE
0665	09	07	*	C'	0705	01	08	T 8	
0666	07	04	RE 4	0706	04	06	$\times 6$		
0667	06	02	SI 2	0707	08	01	*	RE	

0708	01	09	T9	0748	04	06	x6	
0709	04	05	x5	0749	09	15	*	RT
0710	08	01	* RE	0750	09	14	*	EP
0711	01	09	T9					
0712	04	06	x6					
0713	00	02	E2					
0714	00	10	E10					
0715	00	01	E1					
0716	05	05	÷5					
0717	00	02	E2					
0718	00	10	E10					
0719	00	01	E1					
0720	05	06	÷6					
0721	07	03	RE3					
0722	04	05	x5					
0723	07	03	RE3					
0724	04	06	x6					
0725	00	01	E1					
0726	09	15	* RT					
0727	09	00	* M					
0728	11	03	F3					
0729	00	01	E1					
0730	03	02	-2					
0731	15	11	D11					
0732	07	02	RE2					
0733	06	15	ST15					
0734	07	14	RE14					
0735	05	15	÷15					
0736	06	05	ST5					
0737	00	01	E1					
0738	02	02	+2					
0739	15	11	D11					
0740	07	02	RE2					
0741	06	15	ST15					
0742	07	14	RE14					
0743	05	15	÷15					
0744	06	06	ST6					
0745	07	03	RE3					
0746	04	05	x5					
0747	07	03	RE3					

APPENDIX G

S_{12}/S_{21} POLAR COORDINATES-PLOTTING AND LISTING PROGRAM

Verify = 7738

0000	09 00	* M	0040	00 01	E 1
0001	00 01	E 1	0041	00 00	E 0
0002	09 01	* SI	0042	06 07	SI 7
0003	01 04	T 4	0043	00 03	E 3
0004	00 00	E 0	0044	00 07	E 7
0005	06 00	SI 0	0045	00 00	E 0
0006	00 01	E 1	0046	06 08	SI 8
0007	06 01	SI 1	0047	00 00	E 0
0008	09 02	* α	0048	06 04	SI 4
0009	05 08	$\div 8$	0049	06 05	SI 5
0010	02 02	+ 2	0050	00 04	E 4
0011	00 01	E 1	0051	00 04	E 4
0012	00 02	E 2	0052	00 09	E 9
0013	06 01	SI 1	0053	06 06	SI 6
0014	09 02	* α	0054	00 00	E 0
0015	05 10	$\div 10$	0055	06 10	SI 10
0016	02 02	+ 2	0056	06 11	SI 11
0017	00 05	E 5	0057	09 00	* M
0018	00 04	E 4	0058	00 04	E 4
0019	00 07	E 7	0059	07 07	SI 7
0020	06 00	SI 0	0060	08 06	* SI
0021	00 05	E 5	0061	06 00	SI 0
0022	00 06	E 6	0062	07 03	SI 3
0023	00 03	E 3	0063	04 00	$\times 0$
0024	06 01	SI 1	0064	06 12	SI 12
0025	00 04	E 4	0065	07 07	SI 7
0026	00 04	E 4	0066	08 07	* CS
0027	00 09	E 9	0067	06 01	SI 1
0028	06 03	SI 3	0068	07 03	SI 3
0029	09 02	* α	0069	04 01	$\times 1$
0030	05 11	$\div 11$	0070	06 13	SI 13
0031	05 03	$\div 3$	0071	07 05	SI 5
0032	02 02	+ 2	0072	03 00	- 0
0033	00 00	E 0	0073	07 06	SI 6
0034	06 00	SI 0	0074	03 01	- 1
0035	07 03	SI 3	0075	07 12	SI 12
0036	06 01	SI 1	0076	06 05	SI 5
0037	09 02	* α	0077	07 13	SI 13
0038	05 03	$\div 3$	0078	06 06	SI 6
0039	02 02	+ 2	0079	07 10	SI 10

0080	02 00	+0		0120	09 04	* J.
0081	07 11	RE11		0121	08 00	* S
0082	02 01	+1		0122	00 05	E5
0083	09 02	* α		0123	00 03	E3
0084	05 02	$\div 2$		0124	06 14	SI14
0085	02 02	+2		0125	07 04	RE4
0086	07 00	RE0		0126	03 14	-14
0087	06 14	SI14		0127	09 04	* J.
0088	09 12	* I		0128	08 00	* S
0089	03 14	-14		0129	00 06	E6
0090	06 10	SI10		0130	00 04	E4
0091	07 01	RE1		0131	06 14	SI14
0092	06 14	SI14		0132	07 04	RE4
0093	09 12	* I		0133	03 14	-14
0094	03 14	-14		0134	09 04	* J.
0095	06 11	SI11		0135	08 00	* S
0096	00 01	E1		0136	00 07	E7
0097	00 00	E0		0137	00 05	E5
0098	02 07	+7		0138	06 14	SI14
0099	06 14	SI14		0139	07 04	RE4
0100	07 08	RE8		0140	03 14	-14
0101	03 14	-14		0141	09 04	* J.
0102	08 05	* J.		0142	08 00	* S
0103	08 00	* S		0143	00 08	E8
0104	00 04	E4		0144	00 03	E3
0105	00 00	E0		0145	00 05	E5
0106	06 00	SI0		0146	00 09	E9
0107	00 09	E9		0147	06 03	SI3
0108	00 00	E0		0148	00 01	E1
0109	00 12	E12		0149	00 00	E0
0110	06 01	SI1		0150	06 07	SI7
0111	09 02	* α		0151	00 00	E0
0112	05 03	$\div 3$		0152	06 05	SI5
0113	02 02	+2		0153	00 03	E3
0114	00 01	E1		0154	00 05	E5
0115	02 04	+4		0155	00 09	E9
0116	00 02	E2		0156	06 06	SI6
0117	06 14	SI14		0157	08 00	* S
0118	07 04	RE4		0158	00 04	E4
0119	03 14	-14		0159	09 00	* M

0160	00	05	E5	0200	06	07	SI7
0161	00	02	E2	0201	00	00	E0
0162	00	06	E6	0202	06	05	SI5
0163	00	09	E9	0203	00	09	E9
0164	06	03	SI3	0204	00	00	E0
0165	00	01	E1	0205	06	06	SI6
0166	00	00	E0	0206	08	00	* S
0167	06	07	SI7	0207	00	04	E4
0168	00	00	E0	0208	09	00	* M
0169	06	05	SI5	0209	00	08	E8
0170	00	02	E2	0210	00	00	E0
0171	00	06	E6	0211	06	00	SI0
0172	00	09	E9	0212	00	04	E4
0173	06	06	SI6	0213	00	04	E4
0174	08	00	* S	0214	00	09	E9
0175	00	04	E4	0215	06	01	SI1
0176	09	00	* M	0216	09	02	* α
0177	00	06	E6	0217	05	03	$\div 3$
0178	00	01	E1	0218	02	02	+2
0179	00	08	E8	0219	00	08	E8
0180	00	00	E0	0220	00	09	E9
0181	06	03	SI3	0221	00	08	E8
0182	00	01	E1	0222	00	12	E12
0183	00	00	E0	0223	06	01	SI1
0184	06	07	SI7	0224	09	02	* α
0185	00	00	E0	0225	05	02	$\div 2$
0186	06	05	SI5	0226	02	02	+2
0187	00	01	E1	0227	00	04	E4
0188	00	08	E8	0228	00	04	E4
0189	00	00	E0	0229	00	09	E9
0190	06	06	SI6	0230	06	00	SI0
0191	08	00	* S	0231	06	01	SI1
0192	00	04	E4	0232	09	02	* α
0193	09	00	* M	0233	05	03	$\div 3$
0194	00	07	E7	0234	02	02	+2
0195	00	09	E9	0235	00	08	E8
0196	00	00	E0	0236	00	09	E9
0197	06	03	SI3	0237	00	08	E8
0198	00	01	E1	0238	00	12	E12
0199	00	00	E0	0239	06	00	SI0

0240	00	00	E0		0280	06	00	SI0	
0241	06	01	SI1		0281	00	04	E4	
0242	09	02	*	α	0282	00	04	E4	
0243	05	02	$\div 2$		0283	00	08	E8	
0244	02	02	+2		0284	00	12	E12	
0245	00	06	E6		0285	06	01	SI1	
0246	00	01	E1		0286	09	02	*	α
0247	06	00	SI0		0287	05	02	$\div 2$	
0248	00	02	E2		0288	02	02	+2	
0249	00	02	E2		0289	00	01	E1	
0250	00	04	E4		0290	00	06	E6	
0251	06	01	SI1		0291	00	04	E4	
0252	09	02	*	α	0292	06	00	SI0	
0253	05	03	$\div 3$		0293	00	01	E1	
0254	02	02	+2		0294	00	06	E6	
0255	00	07	E7		0295	00	04	E4	
0256	00	07	E7		0296	00	12	E12	
0257	00	06	E6		0297	06	01	SI1	
0258	06	00	SI0		0298	09	02	*	α
0259	00	04	E4		0299	05	03	$\div 3$	
0260	00	04	E4		0300	02	02	+2	
0261	00	08	E8		0301	00	04	E4	
0262	00	12	E12		0302	00	04	E4	
0263	06	01	SI1		0303	00	08	E8	
0264	09	02	*	α	0304	06	00	SI0	
0265	05	02	$\div 2$		0305	00	07	E7	
0266	02	02	+2		0306	00	07	E7	
0267	00	00	E0		0307	00	06	E6	
0268	06	00	SI0		0308	06	01	SI1	
0269	00	04	E4		0309	09	02	*	α
0270	00	04	E4		0310	05	02	$\div 2$	
0271	00	08	E8		0311	02	02	+2	
0272	06	01	SI1		0312	00	04	E4	
0273	09	02	*	α	0313	00	04	E4	
0274	05	03	$\div 3$		0314	00	08	E8	
0275	02	02	+2		0315	00	12	E12	
0276	00	07	E7		0316	06	00	SI0	
0277	00	07	E7		0317	00	00	E0	
0278	00	06	E6		0318	06	01	SI1	
0279	00	12	E12		0319	09	02	*	α

0320	05	03	÷3	0360	09	02	*	α
0321	02	02	+2	0361	05	03	÷3	
0322	00	04	E4	0362	02	02	+2	
0323	00	04	E4	0363	07	14	±14	
0324	00	08	E8	0364	15	02	02	
0325	06	00	SI0	0365	02	02	+2	
0326	00	07	E7	0366	09	02	*	α
0327	00	07	E7	0367	05	11	÷11	
0328	00	06	E6	0368	02	02	+2	
0329	00	12	E12	0369	09	03	*	SP
0330	06	01	SI1					
0331	09	02	* α					
0332	05	02	÷2					
0333	05	11	÷11					
0334	02	02	+2					
0335	08	01	* RE					
0336	01	04	T4					
0337	06	14	SI14					
0338	00	02	E2					
0339	00	00	E0					
0340	05	14	÷14					
0341	09	11	* α					
0342	06	14	SI14					
0343	00	05	E5					
0344	00	04	E4					
0345	00	07	E7					
0346	06	00	SI0					
0347	00	05	E5					
0348	00	06	E6					
0349	00	03	E3					
0350	06	01	SI1					
0351	09	02	* α					
0352	05	03	÷3					
0353	02	02	+2					
0354	00	00	E0					
0355	06	00	SI0					
0356	00	04	E4					
0357	00	06	E6					
0358	00	01	E1					
0359	06	01	SI1					

0370	09	00	*	M
0371	00	02	E2	
0372	09	01	*	SI
0373	01	08	T8	
0374	00	03	E3	
0375	00	00	E0	
0376	06	02	SI2	
0377	09	03	*	SP

0378	09	00	* M	0418	00	01	E 1
0379	10	01	f 1	0419	00	00	E 0
0380	15	13	D13	0420	04	15	x15
0381	07	02	RE2	0421	07	14	RE14
0382	06	14	ST14	0422	08	04	* J6
0383	08	01	* RE	0423	08	00	* S
0384	01	08	T 8	0424	08	06	* J1
0385	05	14	÷14	0425	07	15	RE15
0386	15	11	D11	0426	15	11	D11
0387	06	02	ST2	0427	06	02	ST2
0388	00	01	E 1	0428	00	01	E 1
0389	02	02	+2	0429	02	02	+2
0390	15	13	D13	0430	06	04	ST4
0391	07	01	RE1	0431	09	15	* RT
0392	06	14	ST14				
0393	08	01	* RE				
0394	01	08	T 8				
0395	05	14	÷14				
0396	15	11	D11				
0397	06	02	ST2				
0398	00	01	E 1				
0399	02	02	+2				
0400	15	13	D13				
0401	07	03	RE3				
0402	15	13	D13				
0403	07	03	RE3				
0404	06	14	ST14				
0405	09	02	* α				
0406	11	01	F 1				
0407	09	12	* I				
0408	06	15	ST15				
0409	09	02	* α				
0410	10	01	f 1				
0411	03	14	-14				
0412	00	02	E 2				
0413	02	14	+14				
0414	09	00	* M				
0415	08	06	* J1				
0416	00	01	E 1				
0417	03	14	-14				

0432	09	00	*	M	0472	06	00	ST0
0433	10	02	f2		0473	07	03	RE3
0434	00	00	E0		0474	04	00	x0
0435	06	00	ST0		0475	00	01	E1
0436	00	01	E1		0476	02	02	+2
0437	06	01	ST1		0477	15	11	D11
0438	09	02	*	α	0478	07	02	RE2
0439	05	08	$\div 8$		0479	06	01	ST1
0440	02	02	+2		0480	07	03	RE3
0441	00	01	E1		0481	04	01	x1
0442	00	02	E2		0482	00	02	E2
0443	06	01	ST1		0483	02	02	+2
0444	09	02	*	α	0484	09	02	* α
0445	05	10	$\div 10$		0485	05	03	$\div 3$
0446	02	02	+2		0486	01	06	T6
0447	00	05	E5		0487	02	02	+2
0448	00	04	E4		0488	10	10	f10
0449	00	07	E7		0489	07	04	RE4
0450	06	00	ST0		0490	06	14	ST14
0451	00	05	E5		0491	07	02	RE2
0452	00	06	E6		0492	03	14	-14
0453	00	03	E3		0493	08	04	* J ₀
0454	06	01	ST1		0494	08	00	* S
0455	00	03	E3		0495	00	03	E3
0456	00	00	E0		0496	09	02	* α
0457	06	02	ST2		0497	05	11	$\div 11$
0458	00	04	E4		0498	02	02	+2
0459	00	04	E4		0499	09	03	* SP
0460	00	09	E9		0500	09	00	* M
0461	06	03	ST3		0501	00	03	E3
0462	09	02	*	α	0502	07	10	RE10
0463	05	11	$\div 11$		0503	02	00	+0
0464	05	03	$\div 3$		0504	07	11	RE11
0465	02	02	+2		0505	02	01	+1
0466	01	00	T0		0506	07	00	RE0
0467	01	01	T1		0507	00	12	E12
0468	01	10	T10		0508	06	00	ST0
0469	01	11	T11		0509	07	01	RE1
0470	15	11	D11		0510	00	12	E12
0471	07	02	RE2		0511	06	01	ST1

0512	15	11	D11	0552	07	02	RE2
0513	07	02	RE2	0553	06	14	SI14
0514	06	14	SI14	0554	07	03	RE3
0515	07	03	RE3	0555	04	14	X14
0516	04	14	X14	0556	06	01	SI1
0517	02	00	+0	0557	00	02	E2
0518	00	01	E1	0558	02	02	+2
0519	02	02	+2	0559	07	04	RE4
0520	15	11	D11	0560	06	14	SI14
0521	07	02	RE2	0561	07	02	RE2
0522	06	14	SI14	0562	03	14	-14
0523	07	03	RE3	0563	08	04	* Jb
0524	04	14	X14	0564	08	00	* S
0525	02	01	+1	0565	00	03	E3
0526	00	01	E1	0566	09	02	* α
0527	03	02	-2	0567	05	11	$\div 11$
0528	09	02	* α	0568	02	02	+2
0529	05	03	$\div 3$	0569	09	03	* SP
0530	01	06	T6	0570	09	00	* M
0531	02	02	+2	0571	10	10	f10
0532	10	10	f10	0572	07	00	RE0
0533	07	00	RE0	0573	06	06	SI6
0534	06	14	SI14	0574	07	01	RE1
0535	09	12	* I	0575	06	07	SI7
0536	03	14	-14	0576	00	00	E0
0537	06	10	SI10	0577	06	00	SI0
0538	07	01	RE1	0578	00	01	E1
0539	06	14	SI14	0579	00	02	E2
0540	09	12	* I	0580	00	12	E12
0541	03	14	-14	0581	06	01	SI1
0542	06	11	SI11	0582	09	02	* α
0543	15	11	D11	0583	05	03	$\div 3$
0544	07	02	RE2	0584	02	02	+2
0545	06	14	SI14	0585	07	06	RE6
0546	07	03	RE3	0586	06	00	SI0
0547	04	14	X14	0587	07	07	RE7
0548	06	00	SI0	0588	06	01	SI1
0549	00	01	E1	0589	09	15	* RI
0550	02	02	+2				
0551	15	11	D11				

0590	09	00	*	M	0630	08	07	*	CS
0591	10	03	f3		0631	15	11	D11	
0592	09	02	*	α	0632	07	02	RE2	
0593	05	11	$\div 11$		0633	15	02	D2	
0594	02	02	+2		0634	01	01	T1	
0595	00	09	E9		0635	00	03	E3	
0596	00	09	E9		0636	02	02	+2	
0597	00	09	E9		0637	00	02	E2	
0598	06	00	ST0		0638	00	00	E0	
0599	06	01	ST1		0639	00	12	E12	
0600	09	02	*	α	0640	06	00	ST0	
0601	05	03	$\div 3$		0641	00	01	E1	
0602	02	02	+2		0642	00	09	E9	
0603	00	00	E0		0643	00	02	E2	
0604	06	00	ST0		0644	00	12	E12	
0605	00	01	E1		0645	06	01	ST1	
0606	06	01	ST1		0646	09	02	*	α
0607	09	02	*	α	0647	05	03	$\div 3$	
0608	05	08	$\div 8$		0648	02	02	+2	
0609	02	02	+2		0649	07	02	RE2	
0610	00	00	E0		0650	06	00	ST0	
0611	06	00	ST0		0651	07	04	RE4	
0612	00	01	E1		0652	09	02	*	α
0613	00	02	E2		0653	08	05	*	J
0614	06	01	ST1		0654	08	00	*	S
0615	09	02	*	α	0655	08	07	*	CS
0616	05	10	$\div 10$		0656	07	04	RE4	
0617	02	02	+2		0657	06	02	ST2	
0618	00	00	E0		0658	09	02	*	α
0619	06	00	ST0		0659	05	11	$\div 11$	
0620	00	04	E4		0660	02	02	+2	
0621	00	00	E0		0661	09	15	*	NT
0622	06	01	ST1						
0623	09	02	*	α					
0624	05	03	$\div 3$						
0625	02	02	+2						
0626	00	03	E3						
0627	00	02	E2						
0628	06	02	ST2						
0629	09	00	*	M					

0662	09	00	*	M	0702	00	00	E0
0663	10	04	f4		0703	06	02	ST2
0664	09	02	*	α	0704	09	00	* M
0665	05	11	$\div 11$		0705	09	07	* C'
0666	02	02	+2		0706	15	11	D11
0667	00	05	E5		0707	07	02	RE2
0668	00	01	E1		0708	06	05	ST5
0669	00	00	E0		0709	00	01	E1
0670	06	00	ST0		0710	02	02	+2
0671	00	09	E9		0711	15	11	D11
0672	00	09	E9		0712	07	02	RE2
0673	00	09	E9		0713	06	06	ST6
0674	06	01	ST1		0714	07	05	RE5
0675	09	02	*	α	0715	08	12	* x^2
0676	05	03	$\div 3$		0716	06	14	ST14
0677	02	02	+2		0717	07	06	RE6
0678	00	00	E0		0718	08	12	* x^2
0679	06	00	ST0		0719	02	14	+14
0680	00	04	E4		0720	08	13	* $\sqrt{x}$
0681	00	00	E0		0721	06	10	ST10
0682	06	01	ST1		0722	07	05	RE5
0683	09	02	*	α	0723	06	15	ST15
0684	05	03	$\div 3$		0724	08	01	* RE
0685	02	02	+2		0725	01	04	T4
0686	00	00	E0		0726	06	14	ST14
0687	06	00	ST0		0727	00	02	E2
0688	00	01	E1		0728	00	00	E0
0689	06	01	ST1		0729	05	14	$\div 14$
0690	09	02	*	α	0730	09	11	* $\sqrt{x}$
0691	05	08	$\div 8$		0731	09	01	* ST
0692	02	02	+2		0732	01	05	T5
0693	00	00	E0		0733	08	01	* RE
0694	06	00	ST0		0734	01	05	T5
0695	00	01	E1		0735	04	15	$\times 15$
0696	00	02	E2		0736	08	12	* x^2
0697	06	01	ST1		0737	06	14	ST14
0698	09	02	*	α	0738	07	06	RE6
0699	05	10	$\div 10$		0739	06	15	ST15
0700	02	02	+2		0740	03	01	* RE
0701	00	03	E3		0741	01	05	T5

0742	04	15	$\times 19$	0782	06	14	SI14
0743	08	12	$* x^2$	0783	00	03	E3
0744	02	14	+14	0784	00	06	E6
0745	08	13	$* \sqrt{x}$	0785	00	00	E0
0746	06	08	SI8	0786	06	09	SI9
0747	07	06	$\cdot L6$	0787	07	10	RE10
0748	08	05	$* J_+$	0788	05	14	$\div 14$
0749	08	00	$* S$	0789	09	06	$* S'$
0750	09	06	$* S'$	0790	03	09	-9
0751	07	05	RE5	0791	08	00	$* S$
0752	06	14	SI14	0792	08	11	$* e^x$
0753	08	05	$* J_+$	0793	09	00	$* M$
0754	08	00	$* S$	0794	09	08	$* T'$
0755	08	08	$* IN$	0795	00	12	E12
0756	07	10	RE10	0796	06	14	SI14
0757	05	14	$\div 14$	0797	00	01	E1
0758	09	06	$* S'$	0798	00	08	E8
0759	06	09	SI9	0799	00	00	E0
0760	08	00	$* S$	0800	06	09	SI9
0761	08	11	$* e^x$	0801	07	10	RE10
0762	09	00	$* M$	0802	05	14	$\div 14$
0763	09	06	$* S'$	0803	09	06	$* S'$
0764	07	05	RE5	0804	02	09	+9
0765	06	14	SI14	0805	08	00	$* S$
0766	08	05	$* J_+$	0806	08	11	$* e^x$
0767	08	00	$* S$	0807	09	00	$* M$
0768	09	08	$* T'$	0808	08	11	$* e^x$
0769	00	01	E1	0809	07	08	RE8
0770	00	08	E8	0810	15	02	D2
0771	00	00	E0	0811	03	03	-3
0772	06	09	SI9	0812	00	00	E0
0773	07	10	RE10	0813	06	00	SI0
0774	05	14	$\div 14$	0814	00	01	E1
0775	09	06	$* S'$	0815	00	02	E2
0776	03	09	-9	0816	06	01	SI1
0777	08	00	$* S$	0817	09	02	$* \alpha$
0778	08	11	$* e^x$	0818	05	03	$\div 3$
0779	09	00	$* M$	0819	02	02	+2
0780	08	08	$* IN$	0820	07	09	RE9
0781	00	12	E12	0821	15	02	D2

0822	03	03	-3
0823	00	02	E2
0824	00	00	E0
0825	00	12	E12
0826	06	00	ST0
0827	00	02	E2
0828	00	00	E0
0829	00	04	E4
0830	00	12	E12
0831	06	01	ST1
0832	09	02	* α
0833	05	03	$\div 3$
0834	02	02	+2
0835	00	02	E2
0836	02	02	+2
0837	07	04	RE4
0838	06	14	ST14
0839	07	02	RE2
0840	03	14	-14
0841	08	04	* J_0
0842	08	00	* S
0843	09	07	* c'
0844	07	04	RE4
0845	06	02	ST2
0846	09	02	* α
0847	05	11	$\div 11$
0848	02	02	+2
0849	09	15	* RT
0850	09	14	* EP

APPENDIX H
SCHOTTKY BARRIER CAPACITANCE-PLOTTING AND LISTING PROGRAM

Verify = 7706

0000	09 00	* M	0040	02 02	+2
0001	10 05	f5	0041	00 01	E1
0002	09 02	* α	0042	03 02	-2
0003	05 11	$\div 11$	0043	09 04	* J _s
0004	02 02	+2	0044	08 00	* S
0005	00 09	E9	0045	09 13	* ω
0006	00 08	E8	0046	00 00	E0
0007	06 00	ST0	0047	06 00	ST0
0008	00 01	E1	0048	00 09	E9
0009	00 00	E0	0049	00 00	E0
0010	00 01	E1	0050	06 01	ST1
0011	06 01	ST1	0051	09 02	* α
0012	09 02	* α	0052	05 02	$\div 2$
0013	05 03	$\div 3$	0053	02 02	+2
0014	02 02	+2	0054	08 00	* S
0015	00 01	E1	0055	08 13	* $\sqrt{x}$
0016	00 03	E3	0056	09 00	* M
0017	06 02	ST2	0057	09 13	* ω
0018	09 00	* M	0058	00 00	E0
0019	08 13	* $\sqrt{x}$	0059	06 00	ST0
0020	00 01	E1	0060	00 01	E1
0021	00 00	E0	0061	00 08	E8
0022	06 00	ST0	0062	00 00	E0
0023	00 00	E0	0063	00 12	E12
0024	06 01	ST1	0064	06 01	ST1
0025	09 02	* α	0065	09 02	* α
0026	05 02	$\div 2$	0066	05 02	$\div 2$
0027	02 02	+2	0067	02 02	+2
0028	00 02	E2	0068	00 01	E1
0029	00 00	E0	0069	00 01	E1
0030	00 12	E12	0070	06 02	ST2
0031	06 00	ST0	0071	09 00	* M
0032	09 02	* α	0072	09 11	* ω
0033	05 02	$\div 2$	0073	00 00	E0
0034	02 02	+2	0074	06 00	ST0
0035	00 01	E1	0075	00 01	E1
0036	00 00	E0	0076	00 00	E0
0037	06 00	ST0	0077	06 01	ST1
0038	09 02	* α	0078	09 02	* α
0039	05 02	$\div 2$	0079	05 02	$\div 2$

0080	02	02	+2		0120	09	02	*	α
0081	00	02	E2		0121	05	03	$\div 3$	
0082	00	00	E0		0122	02	02	+2	
0083	00	12	E12		0123	00	01	E1	
0084	06	01	ST1		0124	06	01	ST1	
0085	09	02	*	α	0125	09	02	*	α
0086	05	02	$\div 2$		0126	05	08	$\div 8$	
0087	02	02	+2		0127	02	02	+2	
0088	00	01	E1		0128	00	01	E1	
0089	00	00	E0		0129	00	05	E5	
0090	06	01	ST1		0130	00	12	E12	
0091	09	02	*	α	0131	06	00	ST0	
0092	05	02	$\div 2$		0132	00	00	E0	
0093	02	02	+2		0133	06	01	ST1	
0094	00	01	E1		0134	09	02	*	α
0095	03	02	-2		0135	05	10	$\div 10$	
0096	09	04	*	J ₆	0136	02	12	+12	
0097	08	00	*	S	0137	01	12	T12	
0098	11	06	F6		0138	00	05	E5	
0099	00	09	E9		0139	01	12	T12	
0100	00	00	E0		0140	02	12	+12	
0101	06	00	ST0		0141	01	04	T4	
0102	00	00	E0		0142	02	07	+7	
0103	06	01	ST1		0143	01	12	T12	
0104	09	02	*	α	0144	02	06	+6	
0105	05	02	$\div 2$		0145	02	12	+12	
0106	02	02	+2		0146	02	05	+5	
0107	08	00	*	S	0147	02	02	+2	
0108	09	11	*	M ⁺	0148	00	04	E4	
0109	09	00	*	M	0149	00	00	E0	
0110	11	06	F6		0150	00	00	E0	
0111	00	03	E3		0151	00	12	E12	
0112	00	07	E7		0152	06	00	ST0	
0113	00	00	E0		0153	00	06	E6	
0114	00	12	E12		0154	00	09	E9	
0115	06	00	ST0		0155	00	00	E0	
0116	00	02	E2		0156	00	12	E12	
0117	00	00	E0		0157	06	01	ST1	
0118	00	00	E0		0158	09	02	*	α
0119	06	01	ST1		0159	05	03	$\div 3$	

0160	02	02	+2
0161	00	00	E0
0162	06	00	M0
0163	00	01	E1
0164	00	02	E2
0165	06	01	S1
0166	09	02	* α
0167	02	10	$\div 10$
0168	05	03	$\div 3$
0169	01	14	T14
0170	01	09	T9
0171	03	15	-15
0172	02	07	+7
0173	01	12	T12
0174	00	15	E15
0175	02	05	+5
0176	05	11	$\div 11$
0177	02	02	+2
0178	09	03	* SP

0179	09	00	*	M	0219	07	06	RE 6
0180	10	06	f 6		0220	06	15	ST 15
0181	07	04	RE 4		0221	00	02	E 2
0182	06	03	ST 3		0222	04	15	$\times 15$
0183	00	03	E 3		0223	07	14	RE 14
0184	00	00	E 0		0224	05	15	$\div 15$
0185	06	02	ST 2		0225	00	12	E 12
0186	00	01	E 1		0226	06	15	* $\frac{1}{2}$
0187	06	05	ST 5		0227	06	14	ST 14
0188	09	03	*	SP	0228	00	01	E 1
0189	09	00	*	M	0229	00	00	E 0
0190	08	15	*	$\frac{1}{2}$	0230	00	00	E 0
0191	15	11	D 11		0231	05	14	$\div 14$
0192	06	03	ST 3		0232	09	02	* α
0193	00	01	E 1		0233	10	00	f 0
0194	02	03	+ 3		0234	05	14	$\div 14$
0195	15	11	D 11		0235	07	08	RE 8
0196	07	02	RE 2		0236	05	14	$\div 14$
0197	06	06	ST 6		0237	15	11	D 11
0198	00	01	E 1		0238	06	03	ST 3
0199	02	02	+ 2		0239	00	01	E 1
0200	15	11	D 11		0240	02	03	+ 3
0201	07	02	RE 2		0241	00	01	E 1
0202	06	07	ST 7		0242	02	05	+ 5
0203	00	01	E 1		0243	09	03	* SP
0204	02	02	+ 2		0244	08	00	* S
0205	15	11	D 11		0245	08	15	* $\frac{1}{2}$
0206	07	02	RE 2		0246	09	15	* RT
0207	06	08	ST 8					
0208	00	01	E 1					
0209	02	02	+ 2					
0210	07	06	RE 6					
0211	08	12	* x^2					
0212	06	14	ST 14					
0213	00	01	E 1					
0214	06	15	ST 15					
0215	07	07	RE 7					
0216	03	15	- 15					
0217	08	12	* x^2					
0218	02	14	+ 14					

0247	09	00	*	M	0287	07	15	RE15	
0248	10	07	f 7		0288	06	09	SI 9	
0249	09	02	*	α	0289	15	02	D 2	
0250	05	11	$\div 11$		0290	02	02	+ 2	
0251	02	02	+ 2		0291	00	10	E 10	
0252	00	08	E 8		0292	00	08	E 8	
0253	00	01	E 1		0293	06	06	ST 6	
0254	06	00	ST 0		0294	00	05	E 5	
0255	00	06	E 6		0295	06	02	ST 2	
0256	00	03	E 3		0296	09	00	*	M
0257	06	01	ST 1		0297	11	10	F 10	
0258	09	02	*	α	0298	07	15	RE15	
0259	05	03	$\div 3$		0299	06	14	ST 14	
0260	02	02	+ 2		0300	07	06	RE 6	
0261	00	01	E 1		0301	04	14	$\times 14$	
0262	06	01	ST 1		0302	00	10	E 10	
0263	09	02	*	α	0303	00	02	E 2	
0264	05	08	$\div 8$		0304	03	06	- 6	
0265	02	02	+ 2		0305	00	01	E 1	
0266	00	00	E 0		0306	03	02	- 2	
0267	06	00	ST 0		0307	09	04	*	J ₆
0268	00	01	E 1		0308	08	00	*	S
0269	00	02	E 2		0309	11	11	F 11	
0270	06	01	ST 1		0310	00	00	E 0	
0271	09	02	*	α	0311	06	00	ST 0	
0272	05	10	$\div 10$		0312	00	01	E 1	
0273	02	02	+ 2		0313	00	00	E 0	
0274	07	04	RE 4		0314	00	08	E 8	
0275	06	02	ST 2		0315	06	01	ST 1	
0276	15	11	D 11		0316	09	02	*	α
0277	07	02	RE 2		0317	05	03	$\div 3$	
0278	06	07	ST 7		0318	02	02	+ 2	
0279	09	13	*	IXI	0319	07	14	RE 14	
0280	06	06	ST 6		0320	15	02	D 2	
0281	00	02	E 2		0321	02	02	+ 2	
0282	02	02	+ 2		0322	08	00	*	S
0283	08	00	*	S	0323	11	10	F 10	
0284	11	12	F 12		0324	09	00	*	M
0285	09	00	*	M	0325	11	11	F 11	
0286	11	04	F 4		0326	00	01	E 1	

0327	00	03	E3		0367	03	06	-6
0328	00	00	E0		0368	08	05	* J
0329	06	01	ST1		0369	08	00	* S
0330	09	02	*	α	0370	11	13	F13
0331	05	03	$\div 3$		0371	07	07	RE7
0332	03	01	-1		0372	09	13	* IXI
0333	01	06	T6		0373	06	06	ST6
0334	03	01	-1		0374	00	02	E2
0335	03	01	-1		0375	02	02	+2
0336	02	02	+2		0376	07	03	RE3
0337	00	01	E1		0377	06	14	ST14
0338	00	01	E1		0378	07	02	RE2
0339	00	00	E0		0379	03	14	-14
0340	06	01	ST1		0380	00	01	E1
0341	09	02	*	α	0381	03	14	-14
0342	05	03	$\div 3$		0382	08	05	* J
0343	02	02	+2		0383	08	00	* S
0344	07	15	RE15		0384	11	14	F14
0345	06	14	ST14		0385	08	00	* S
0346	00	10	E10		0386	11	12	F12
0347	00	02	E2		0387	09	00	* M
0348	04	14	$\times 14$		0388	11	13	F13
0349	00	12	E12		0389	15	11	D11
0350	15	02	D2		0390	07	02	RE2
0351	02	02	+2		0391	06	07	ST7
0352	07	04	RE4		0392	09	13	* IXI
0353	06	02	ST2		0393	06	06	ST6
0354	00	01	E1		0394	00	02	E2
0355	02	02	+2		0395	02	02	+2
0356	15	11	D11		0396	07	03	RE3
0357	07	02	RE2		0397	06	14	ST14
0358	06	06	ST6		0398	07	02	RE2
0359	06	07	ST7		0399	03	14	-14
0360	00	02	E2		0400	00	01	E1
0361	02	02	+2		0401	03	14	-14
0362	09	00	*	M	0402	08	05	* J
0363	11	12	F12		0403	08	00	* S
0364	15	11	D11		0404	11	14	F14
0365	07	02	RE2		0405	08	00	* S
0366	09	13	*	IXI	0406	11	12	F12

0407	09	00	* M	0447	00	12	E12
0408	11	14	F14	0448	06	01	ST1
0409	07	07	RE7	0449	09	02	* α
0410	06	15	ST15	0450	05	03	$\div 3$
0411	00	01	E1	0451	02	02	+2
0412	02	14	+14	0452	00	02	E2
0413	09	04	* J ₀	0453	03	14	-14
0414	08	00	* S	0454	08	04	* J ₀
0415	11	04	F4	0455	08	00	* S
0416	09	00	* M	0456	11	01	F1
0417	11	15	F15	0457	09	00	* M
0418	07	15	RE15	0458	11	02	F2
0419	09	12	* I	0459	00	02	E2
0420	08	04	* J ₀	0460	00	10	E10
0421	08	00	* S	0461	00	05	E5
0422	11	00	F0	0462	06	14	ST14
0423	00	01	E1	0463	06	15	ST15
0424	00	00	E0	0464	06	08	ST8
0425	04	15	$\times 15$	0465	15	02	D2
0426	08	00	* S	0466	01	01	T1
0427	11	15	F15	0467	08	00	* S
0428	09	00	* M	0468	11	03	F3
0429	11	00	F0	0469	09	00	* M
0430	06	14	ST14	0470	11	01	F1
0431	07	15	RE15	0471	00	05	E5
0432	03	14	-14	0472	06	14	ST14
0433	00	01	E1	0473	06	15	ST15
0434	02	14	+14	0474	06	08	ST8
0435	02	15	+15	0475	15	02	D2
0436	06	14	ST14	0476	01	01	T1
0437	00	10	E10	0477	09	00	* M
0438	00	08	E8	0478	11	03	F3
0439	06	02	ST2	0479	00	01	E1
0440	00	09	E9	0480	00	08	E8
0441	00	01	E1	0481	00	00	E0
0442	00	08	E8	0482	00	12	E12
0443	06	00	ST0	0483	06	00	ST0
0444	00	02	E2	0484	00	04	E4
0445	00	00	E0	0485	00	08	E8
0446	00	00	E0	0486	00	12	E12

0487	06	01	SI 1
0488	09	02	* α
0489	05	03	$\div 3$
0490	02	02	+2
0491	07	15	RE15
0492	06	14	SI14
0493	07	02	RE 2
0494	04	14	$\times 14$
0495	15	02	D2
0496	01	01	T 1
0497	00	10	E10
0498	00	02	E2
0499	03	02	-2
0500	09	04	* J.
0501	08	00	* S
0502	11	07	F7
0503	08	00	* S
0504	11	03	F3
0505	09	00	* M
0506	11	07	F7
0507	09	02	* α
0508	05	11	$\div 11$
0509	02	02	+2
0510	09	03	* SP

0511	09	00	*	M	0551	07	10	RE10
0512	10	08	f8		0552	05	09	÷9
0513	00	01	E1		0553	08	15	* ½
0514	00	00	E0		0554	09	13	* IXI
0515	00	01	E1		0555	06	09	ST9
0516	06	00	ST0		0556	00	00	E0
0517	00	09	E9		0557	06	00	ST0
0518	00	09	E9		0558	06	01	ST1
0519	00	09	E9		0559	06	10	ST10
0520	06	01	ST1		0560	06	11	ST11
0521	09	02	*	α	0561	15	11	D11
0522	05	03	÷3		0562	07	02	RE2
0523	02	02	+2		0563	06	01	ST1
0524	00	01	E1		0564	07	09	RE9
0525	06	01	ST1		0565	04	01	×1
0526	09	02	*	α	0566	00	01	E1
0527	05	08	÷8		0567	02	02	+2
0528	02	02	+2		0568	15	11	D11
0529	00	00	E0		0569	07	02	RE2
0530	06	00	ST0		0570	06	00	ST0
0531	00	01	E1		0571	07	08	RE8
0532	00	02	E2		0572	04	00	×0
0533	06	01	ST1		0573	00	01	E1
0534	09	02	*	α	0574	02	02	+2
0535	05	10	÷10		0575	09	02	* α
0536	02	02	+2		0576	05	03	÷3
0537	07	04	RE4		0577	01	06	T6
0538	06	02	ST2		0578	02	02	+2
0539	00	08	E8		0579	11	09	F9
0540	00	09	E9		0580	07	03	RE3
0541	00	08	E8		0581	06	14	ST14
0542	06	10	ST10		0582	07	02	RE2
0543	05	08	÷8		0583	03	14	-14
0544	08	15	* ½		0584	08	04	* Jo
0545	06	08	ST8		0585	08	00	* S
0546	00	01	E1		0586	11	08	F8
0547	00	11	E11		0587	09	02	* α
0548	00	01	E1		0588	05	11	÷11
0549	00	02	E2		0589	02	02	+2
0550	04	08	×8		0590	09	03	* SP

0591	09	00	*	M	0631	09	12	*	I
0592	11	08	F 8		0632	03	14	-14	
0593	07	10	RE 10		0633	06	11	ST 11	
0594	02	00	+ 0		0634	15	11	D 11	
0595	07	11	RE 11		0635	07	02	RE 2	
0596	02	01	+ 1		0636	06	14	ST 14	
0597	07	00	RE 0		0637	07	09	RE 9	
0598	00	12	E 12		0638	04	14	x 14	
0599	06	00	ST 0		0639	06	01	ST 1	
0600	07	01	RE 1		0640	00	01	E 1	
0601	00	12	E 12		0641	02	02	+ 2	
0602	06	01	ST 1		0642	15	11	D 11	
0603	15	11	D 11		0643	07	02	RE 2	
0604	07	02	RE 2		0644	06	14	ST 14	
0605	06	14	ST 14		0645	07	08	RE 8	
0606	07	09	RE 9		0646	04	14	x 14	
0607	04	14	x 14		0647	06	00	ST 0	
0608	02	01	+ 1		0648	00	01	E 1	
0609	00	01	E 1		0649	02	02	+ 2	
0610	02	02	+ 2		0650	07	03	RE 3	
0611	15	11	D 11		0651	06	14	ST 14	
0612	07	02	RE 2		0652	07	02	RE 2	
0613	06	14	ST 14		0653	03	14	-14	
0614	07	08	RE 8		0654	08	04	* J ₆	
0615	04	14	x 14		0655	08	00	* S	
0616	02	00	+ 0		0656	11	08	F 8	
0617	00	01	E 1		0657	09	02	* α	
0618	03	02	- 2		0658	05	11	÷ 11	
0619	09	02	* α		0659	02	02	+ 2	
0620	05	03	÷ 3		0660	09	03	* SP	
0621	01	06	T 6		0661	09	00	* M	
0622	02	02	+ 2		0662	11	09	F 9	
0623	11	09	F 9		0663	07	00	RE 0	
0624	07	00	RE 0		0664	06	06	ST 6	
0625	06	14	ST 14		0665	07	01	RE 1	
0626	09	12	* I		0666	06	07	ST 7	
0627	03	14	-14		0667	00	00	E 0	
0628	06	10	ST 10		0668	06	00	ST 0	
0629	07	01	RE 1		0669	00	01	E 1	
0630	06	14	ST 14		0670	00	02	E 2	

0671	00	12	E12
0672	06	01	ST 1
0673	09	02	* α
0674	05	03	$\div 3$
0675	02	02	+ 2
0676	07	06	RE 6
0677	06	00	ST 0
0678	07	07	RE 7
0679	06	01	ST 1
0680	09	15	* RT
0681	09	03	* SP

0682	09	00	*	M	0722	02	12	+12	
0683	10	09	f9		0723	01	09	T9	
0684	09	02	*	α	0724	00	14	E14	
0685	05	11	$\div 11$		0725	01	12	T12	
0686	02	02	+2		0726	01	13	T13	
0687	00	09	E9		0727	01	12	T12	
0688	00	09	E9		0728	02	13	+13	
0689	00	09	E9		0729	01	01	T1	
0690	06	00	ST0		0730	02	02	+2	
0691	00	01	E1		0731	00	02	E2	
0692	00	00	E0		0732	00	00	E0	
0693	00	01	E1		0733	00	12	E12	
0694	06	01	ST1		0734	06	00	ST0	
0695	09	02	*	α	0735	00	02	E2	
0696	05	03	$\div 3$		0736	00	04	E4	
0697	02	02	+2		0737	00	00	E0	
0698	00	00	E0		0738	00	12	E12	
0699	06	00	ST0		0739	06	01	ST1	
0700	00	01	E1		0740	09	02	*	α
0701	06	01	ST1		0741	05	03	$\div 3$	
0702	09	02	*	α	0742	02	02	+2	
0703	05	08	$\div 8$		0743	07	04	RE4	
0704	02	02	+2		0744	06	02	ST2	
0705	00	01	E1		0745	09	00	*	M
0706	00	02	E2		0746	10	15	f15	
0707	06	01	ST1		0747	15	11	D11	
0708	09	02	*	α	0748	07	02	RE2	
0709	05	10	$\div 10$		0749	15	02	D2	
0710	01	14	T14		0750	02	02	+2	
0711	01	09	T9		0751	00	00	E0	
0712	03	15	-15		0752	06	00	ST0	
0713	02	07	+7		0753	00	03	E3	
0714	01	01	T1		0754	00	00	E0	
0715	05	03	$\div 3$		0755	06	01	ST1	
0716	05	03	$\div 3$		0756	09	02	*	α
0717	05	03	$\div 3$		0757	05	03	$\div 3$	
0718	05	03	$\div 3$		0758	02	02	+2	
0719	05	03	$\div 3$		0759	00	01	E1	
0720	00	05	E5		0760	02	02	+2	
0721	01	04	T4		0761	15	11	D11	

0762	07	02	FE2
0763	06	14	SI14
0764	00	01	E1
0765	00	11	E11
0766	00	01	E1
0767	00	02	E2
0768	04	14	x14
0769	15	02	D2
0770	01	02	T2
0771	00	02	E2
0772	00	00	E0
0773	00	12	E12
0774	06	00	SI0
0775	00	01	E1
0776	00	06	E6
0777	00	02	E2
0778	00	12	E12
0779	06	01	SI1
0780	09	02	* α
0781	05	03	$\div 3$
0782	02	02	+2
0783	00	01	E1
0784	02	02	+2
0785	06	14	SI14
0786	07	03	RE3
0787	03	14	-14
0788	08	04	* J_6
0789	08	00	* S
0790	10	15	f15
0791	09	02	* α
0792	05	11	$\div 11$
0793	02	02	+2
0794	09	03	* SP
0795	09	14	* EP

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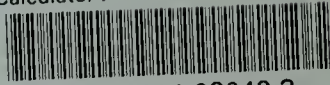
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